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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIII.—No. 2939.] *LONDON: FRIDAY, APRIL 28, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Illustrated Advertisement Page 100, Jan. 28, 1921.

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See page 17, April 21. 9947

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See Advertisement page 75.

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See Advertisement, page 30. 9952

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HIGH BOILER EFFICIENCIES
ARE OBTAINED BY INSTALLING
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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

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&c. &c. 9034

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See Advertisement page 57, April 21. 3402

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9737
See half-page Advertisement page 42, April 14.

See Advt. Page 80 April 21.
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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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TENDERS.

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

OLD LOCOMOTIVES FOR SALE.

The Midland Great Western Railway Company

Offer for Sale as Scrap 10 OLD LOCOMOTIVES and TENDERS. Approximate weight of one engine and tender, 50 tons. In addition to the usual brass bearings and boiler mountings, each boiler contains about 30 cwts. copper.

The scrap copper will be re-purchased by the Company at the price current when the material is available.

Engines can be inspected at Broadstone Station, Dublin, on application to the Company's Locomotive Engineer.

Offers for purchase, sealed and endorsed "Old Locomotives," to be addressed to the Chairman, M. G. W. Railway, Broadstone Terminus, Dublin, and posted so as to reach him by the 15th May, 1922.

PERCY A. HAY, Secretary.
Broadstone Terminus, Dublin.
21st April, 1922. U 42

SOUTH AFRICAN RAILWAYS AND HARBOURS.

ELECTRIFICATION OF GLENCOE—PIETERMARITZBURG SECTION.

Tenders are Invited for Steel FRAME BUILDINGS for Power Station.

Specifications and Forms of Tender may be obtained at the Office of the HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA, Trafalgar Square, W.C. 2, on and after the 26th April, 1922.

The Consulting Engineers, to whom applications for further technical information may be made, are Messrs. MERZ and MCLELLAN, 32, Victoria Street, London, S.W. 1.

The charge for each specification is Five Guineas for the first copy, and Two Guineas each for any further copies. Sums paid for any number of specifications up to three will be refunded on receipt of *bona fide* Tenders. Sums paid for copies of the Specification beyond three will not be refunded.

Sealed Tenders, marked "Tender C 933" are to be addressed to The SECRETARY, Office of the High Commissioner for the Union of South Africa, and lodged at the above address not later than noon on 26th June, 1922.

The South African Railways Administration does not bind itself to accept the lowest, or any Tender. U 81

PORT OF BRISTOL.

GRAIN HANDLING MACHINERY, NEW GRANARY, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee are prepared to receive

Tenders for the Construction and ERECTION on site of GRAIN HANDLING MACHINERY for the New Granary, Royal Edward Dock, Avonmouth. The Machinery consists of elevators and conveyors and includes motors and switchgear for driving the same.

On and after Friday, the 28th April, 1922, copies of the Specification and Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £2 has been paid. All cheques must be made payable to "The Bristol Docks Committee" and forwarded to the General Manager and Secretary, Dock Office, 19, Queen Square, Bristol. The deposit will be returned to *bona fide* Tenderers after the receipt of the Tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Grain Handling Machinery" and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Tuesday, the 23rd May, 1922.

The Docks Committee do not bind themselves to accept the lowest or any Tender,

THOMAS A. PEACH, Engineer.
Engineer's Office,
Avonmouth Docks.
20th April, 1922. T 998

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of:—
STEEL BOILER TUBES.

Forms of Tender may be obtained from the Director-General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m. on Tuesday, the 16th May, 1922.

T. RYAN, Director-General. U 76

THE ROSS LOCKNUT CO. LTD.

The Receiver for the Debenture Holders invites

Tenders for the Purchase by Private Treaty of the Assets of the Ross Locknut Company, consisting of Home and Foreign Patents, a list of which can be obtained from the Receiver at the undermentioned address or at the Company's office, Billiter Square Buildings, London, E.C. 3.

HAROLD MAYHEW (Receiver),
38, Waterloo Street,
Birmingham. U 49

EAST INDIAN RAILWAY.

The Directors are prepared to receive up to Eleven o'clock a.m. on Wednesday, the 17th May proximo,

Tenders for the Supply of GIRDER BRIDGES.

Copies of the specification can be obtained at the Company's Offices on payment of £1 1s. 0d. each. This fee will not be returned.

G. H. LILLIE, Secretary.
28/30, Nicholas Lane,
London, E.C. 4.
26th April, 1922. U 85

BRADFORD CORPORATION.

THE TRAMWAYS DEPARTMENT have

For Disposal, Three Second- hand PETROL LORRIES, as under:—
One Durham Churchill, carrying capacity 3 tons.
One Durham Churchill, carrying capacity 2 tons.
One Dennis, carrying capacity 1½ tons.

These vehicles are all fitted with lorry bodies, driver's cab, wind screen, canvas covers to bodies. All in good running order, and complete in every detail.

Full particulars, specification and permission to view can be obtained on application to the Tramways General Manager, 7, Hall Ings, Bradford.

Tenders for either or all of these vehicles to be endorsed "Tramways-Lorries," and sent to the TOWN CLERK, Town Hall, Bradford, not later than Saturday, 20th May, 1922. U 84

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—
(a) WOOD SCREWS, NAILS, etc. (10,926 gross Wood Screws. Tons 6.12, Nails, etc., etc.)
(b) Tons 83.8, SPRING STEEL.
(c) Tons 45 RED AND WHITE LEAD. (14 Tons Red, 31 Tons White).

For each copy of the Specification (a) a fee of 10/- will be charged, and for each copy of the Specifications (b) and (c) a fee of 20/- will be charged, which fees are not returnable. Tenders enclosed in sealed envelopes endorsed "Tender for Wood Screws, Nails, etc.," or as the case may be, must be delivered at the Company's Offices not later than twelve noon on Monday, 8th May, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

Parts of each of the above requirements are urgently wanted in Burma.

By Order of the Board,
F. C. FRANKS, Secretary.
199, Gresham House,
Old Broad Street,
London, E.C. 2.
27th April, 1922. U 80

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

No.		Fee for Specification.
1.	Mild Steel Bars, &c.,	£1
2.	Straight Axles (forgings) for Engines and Tenders,	5s. 0d.
3.	Bolts, Nuts, Rivets, &c.	£1
4.	Rolled Steel Disc Wheels,	7s. 6d.
5.	Acid open hearth steel Boiler Plates,	5s. 0d.
6.	Anvils,	2s. 6d.
7.	Pin Crows,	2s. 6d.
8.	Canvas Hose Pipes,	5s. 0d.
9.	Leather Belting, &c.	10s. 0d.
10.	Station Bells, bibcocks, &c.,	5s. 0d.
11.	Platelayers Tools,	10s. 0d.
12.	Wood Handles,	10s. 0d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Mild Steel Bars, &c.," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 9th May, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.
Company's Offices,
48, Copthall Avenue, London, E.C. 2.
26th April, 1922. U 86

APPOINTMENTS OPEN.

Engineering Instructor REQUIRED, London, as Principal. Some capital an advantage.—Address, U 62, Offices of ENGINEERING.

UNIVERSITY COLLEGE OF SWANSEA.

Applications are Invited for the POST of LECTURER in Civil Engineering. Salary £500 per annum. The appointment will date from October 1, 1922.

Further particulars may be obtained from the undersigned, by whom applications must be received on or before May 13, 1922.

EDWIN DREW, Registrar.
Singleton Park, Swansea.
April, 1922. T 985

COUNTY BOROUGH OF GREAT YARMOUTH.

TRAMWAYS MANAGER.

Applications are Invited for the POST of TRAMWAYS MANAGER (Engineer preferred), to take entire charge of the Corporation's Tramway Undertaking, outside the Power Station, with the exception of the maintenance and control of the overhead Electrical Equipment. Salary £400 per annum. Canvassing is prohibited.

Applications, which should state experience in permanent way work, and be accompanied by a copy of three testimonials, must reach me not later than Noon on Tuesday, 2nd May.

W. EDGAR STEPHENS, Town Clerk,
Town Hall,
Great Yarmouth,
20th April, 1922. U 16

Engineer, with extensive knowledge of Storage and Handling of Grain. Must have had experience in planning and carrying out large contracts. Knowledge of foreign requirements essential. Experienced in negotiating important business abroad. Liberal salary and good prospects.—BOX 580, Advertising Offices, 54, Queen Victoria Street, London, E.C. 4. U 44

Wanted, an Engineer, structural or reinforced concrete preferred, with organising, executive and commercial abilities, to initiate with advertiser big scheme in lucrative industry. Must be prepared to speculate £500. Exceptional opportunity of fine future for gentleman of energy, brains and imagination.

Should be worth from £2000 per annum up for the right man.

Age 30 to 40.
Address, U 88, Offices of ENGINEERING.

Coal Handling.—Required, Competent ENGINEER, of French nationality, with knowledge of electric transporters, generating plant and coal screening, to take charge of small installation at Rouen. Able to handle labour and speak English.—Address, U 48, Offices of ENGINEERING.

Assistant Engineer Estimator REQUIRED for Contractors' Plant manufacturers; must be good correspondent and reliable with figures. State age, qualifications and salary required.—Address, U 72, Offices of ENGINEERING.

Heating and Ventilating.— Required by London Firm of Engineers. Competent Supervising ENGINEER, capable of estimating and taking full control of Contracts. A wide experience of the business essential. Write fully, stating age, experience and salary required. —Address, U 83, Offices of ENGINEERING.

Wanted, Works Manager, by an old-established firm of manufacturers who specialise in railway track requisites and in bridge-building. Only man possessing sound knowledge of economical design and of modern shop management need apply.—BOX 6256, c/o BROWN'S, 29, Tothill Street, S.W. 1. U 34

Required for London Office, (Victoria) of a Company manufacturing a patented meter and calorimeter for Gas Works, a YOUNG ENGINEER with knowledge of modern Gas Works practice, and if possible with selling experience. The position offered is permanent, and has considerable scope to the right man.—Address, stating age, salary required, experience, &c., U 39, Offices of ENGINEERING.

CITY OF BRADFORD.

CHIEF ASSISTANT ELECTRICAL ENGINEER.

Applications are Invited for the POST of CHIEF ASSISTANT ELECTRICAL ENGINEER in the Electricity Department of the Bradford Corporation.

The person appointed is required to assist the City Electrical Engineer and Manager in all engineering matters, but principally in connection with the generation and distribution of electrical energy.

Applicants must have received a sound technical education, and have practical knowledge of the design and operation of electrical generating and converting plant and transmission and distribution systems.

The salary attached to the post is £725 per annum.

The successful candidate will be required to devote his whole time to the duties of the office, and to reside within the city.

Canvassing members of the Council will be a disqualification.

Lists of Duties and Forms, on which applications are to be made may be obtained from Mr. THOMAS ROLES, City Electrical Engineer and Manager, Town Hall, Bradford.

Applications, endorsed "Chief Assistant Electrical Engineer," accompanied by COPIES of not more than three testimonials (which will not be returned), to be sent in time to reach me not later than the first post on Thursday, 11th May, 1922.

R. L. FLEMMING, Town Clerk.
Town Hall, Bradford,
26th April, 1922. U 81

Jig and Tool Draughtsman WANTED for Motor Car work. Give full particulars of experience, salary required and age. —Address, U 87, Offices of ENGINEERING.

Wanted, Mechanical DRAUGHTSMAN used to General Plant Engineering. Works' experience essential. Preference given to man having knowledge of Chemical Plant.—Address, U 79, Offices of ENGINEERING.

Assistant to Chief Designer, must be thoroughly conversant with kinetic and strength calculations and specially qualified to deal with design and experimental work on small complex mechanisms.—Address, U 78, Offices of ENGINEERING.

Wanted, by a Port Authority, a fully qualified CHIEF DRAUGHTSMAN in the Chief Engineer's Office, age about 35-40 years. Salary £700 per annum. Applicants should state fully their experience in designing and construction of docks, buildings, constructional steelwork, bridges, reinforced concrete, surveying and quantity surveying; also if disengaged or how soon they could take up duty. Applicants should be competent to take control of drawing office staff, and should state fully their experience, accompanied by references.—Address, U 8, Offices of ENGINEERING.

Control Apparatus Designer.— EXPERIENCED MAN REQUIRED, capable of working out designs of Traction Control Apparatus from a Specification with scheme of connections; experience of modern locomotive control gear essential; knowledge of manufacturing methods an advantage; must be a good disciplinarian, State age, technical training, experience, and salary required.—Address, T 973, Offices of ENGINEERING.

Required, for Consulting Engineers' Office in Westminster, the following Temporary Staff:—(1) DRAUGHTSMAN, structural steelwork, capable of calculating and designing the steelwork of workshop buildings, power houses, etc. (2) DRAUGHTSMAN, mechanical, for lay-out of workshops and plant and the design of power houses. Applicants, who should preferably have had extensive experience in connection with the lay-out of large railway or other workshops, and should be between the ages of 27 and 45, should submit a short statement giving particulars of their age, education, training and experience, together with particulars of the salary required, to BOX 6265, c/o BROWN'S, 29, Tothill Street, S.W. 1. U 51

Traveller Required, for Wrought Tubes, Fittings, &c., in London district. Must have good connection. One with engineering knowledge preferred. Good opportunity for the right man. Write in strict confidence, giving age, experience, and salary required. —Address, U 29, Offices of ENGINEERING.

Agents Wanted for following territories to handle Engineering Speciality on commission:—
1. South Coast (Kent, Sussex, Hants and Dorset to Poole).
2. Oxford District. Territory approximately 25 miles radius from Oxford.

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THE REPAIR OF THE NEW YORK-BROOKLYN SUBMARINE WATER MAIN.

STATEN ISLAND, otherwise known as the Borough of Richmond of the City of Greater New York, obtains its fresh water supply from the Catskill Mountains, 120 miles distant. This is made possible by subaqueous piping, buried in the harbour bottom, and spanning the interval of 10,000 ft., between the Brooklyn and the Staten Island shores. On February 2, 1922, this cast-iron pipe, of an internal diameter of 36 in., was damaged by a dredge then working close by the Staten Island side of The Narrows, under which the water piping is laid. The pipe at the point of injury rests 53 ft. below the surface and beneath 20-odd ft. of mud, and was fractured badly at the top of one of the 12-ft. lengths. The gaping rupture necessitated the prompt closing of the valves at both ends of the submerged pipe line, thus cutting off the 125,000 inhabitants of Staten Island from their regular supply of water from the distant mountains. Although the local reservoir, containing 435,000,000 gallons of water, was filled at the time, the situation was nevertheless a serious one, and demanded the repair of the pipe line with all practical despatch.

In removing the damaged section, it was essential that the remaining undamaged piping should not be disturbed. In their dilemma, the engineering authorities of the Municipal Water Supply Department called on the Merritt and Chapman Derrick and Wrecking Company—who had laid this line in 1916—to come to their assistance. This firm decided to undertake the repair on rather unusual lines; their plan calling for very extensive metal cutting to be done under water. For this purpose they decided to employ a new form of submarine electric burning torch with which they had experimented for some time and which was finally made to operate successfully. The alternative method was cutting by cold chisel and compressed air, which would have caused considerable loss of time and thereby great inconvenience to the public. The use of dynamite was not recommended owing to possible damage to the remaining piping through shock.

The submarine electric burning torch is an evolution of an oxy-acetylene electric torch devised by two of the firm's engineering staff in 1918 while engaged in the righting and the refloating of the transatlantic liner St. Paul, which had turned over and sunk at her dock just after reaching her pier from an overhauling yard in Brooklyn. The burner used at that time was the outcome of efforts to develop a reliable submarine torch or under-water cutting device. The electrical feature made it possible to carry the torch in an inert state under water to the point of service and then to switch on current when the operator was ready to begin cutting. To reach their submerged objectives within the steamer St. Paul, where 12 large holes were cut through steel bulkheads, the divers were obliged to follow more or less tortuous routes and to walk upon sharply slanting metal surfaces covered with slippery mud. It would have been out of the question to employ a burner such as the Germans had used some years earlier in experimental work. Before this torch was available, the salvors on the steamer St. Paul had made other passages for draining off water by blasting holes in steel partitions. That time-honoured procedure did much more damage than necessary, and imposed correspondingly greater outlays afterwards in making repairs. The Chapman-Kirk burner was utilised within the steamer St. Paul at a maximum depth of about 50 ft. However, trouble was experienced in operating the burner when approaching that depth, owing to the uncertain action of the gas. The acetylene would not burn steadily, and, without warning, it was apt to ignite explosively and to blow out the flame.

In the years that have intervened, Mr. Ralph E. Chapman has confined his researches principally to discovering a gas devoid of the shortcomings of the oxy-acetylene mixture, and in this he has been successful. The function of the gas is to supplement the fusing heat of the electric arc; to remove the plastic metal; and to form a gaseous envelope about the arc at any desired depth. Mr. Chapman is not disposed at present to disclose the character of the "cutting gas"; but we are informed that it has performed satisfactorily on heavy cast steel lying 70 ft. below the surface. To fulfil its office, the pressure of the gas has to be considerably higher than that of the hydrostatic head in order to keep the surrounding water away from the arc. This explains why acetylene has proved unfitted for such work—the gas becoming an explosive when ignited at a pressure of about 30 lb.

The burners employed to perform the cutting on The Narrows water piping were adapted, after some preliminary testing, to deal with the rather high melting point required in re-melting cast-iron. The present submarine burner develops at the arc a temperature of more than 6,000 deg. F.; and this was found to be ample to effect the cutting of the cast-iron piping at an average depth of 50 ft. The water at the time was close to the freezing-point. After the overlying mud was cleared away for a goodly radius about the fractured pipe length, the divers commenced to work with their burners. Their operations centred upon the execution of three tasks: To enlarge the breach to permit activities inside the pipe; to remove a big sector of the bell of the damaged pipe; and to completely sever, by an encircling cut, an adjoining sound section. The several cuts are indicated on the accompanying illustrations, Figs. 1 and 2. All told, the burners made cuts aggregating over 30 linear feet through cast iron ranging from 1¼ in. to 3½ in. in thickness. This phase of the undertaking was accomplished inside of nine days, but the time would have been much less had the material been anything but cast-iron.

The lower part of the encircling cut was made from within the pipe, but the remainder of the cutting was done from outside the piping. Before clearing away the upper sector of the bell end of the damaged pipe it was necessary to sever, at two points, a wrought iron band, 1½ in. thick and 4 in. wide. This band had been shrunk on the lip of the bell for reinforcement. The ring was released by a single diver in the course of one day's work; and the performance was convincing evidence of the effectiveness of the submarine burner. In cutting through the cast-iron, the divers made headway at the rate of from 4 in. to 6 in. an hour, depending upon the thickness of the metal, the temperature of the water, and the ease with which they could reach their objectives.

The purpose in cutting away the sector of the bell was to facilitate detaching the fractured pipe length when its opposite end was raised. In laying the piping in 1916, each joint was packed with lead and the connection further secured by a series of gib screws extending through the flare and into grooves cast in the spigot end of the enveloped pipe section. This particular joint of the broken pipe had to be freed with a minimum of shock or violence so as not to impair any of the joints beyond. When the fractured section of piping was lifted, after the cutting was finished, the remaining portion of the bell dropped away without having to exert force. The section of the broken pipe which was cut out in this way is shown, raised to the surface, in Fig. 6, page 510. Undoubtedly, the use of submarine burners on this job greatly expedited the fitting of a new section of piping and rendered it practicable to minimise the repairs and thus reduce the costs.

The placing of a new section was begun as soon as the injured piping was removed; and the renewal of the broken pipe called for special care. The sections adjoining the fractured pipe had been forced down and displaced by the dredge at the time of the accident, but the deflection had not been in excess of the 5 deg. flexure for which allowance had been made originally in designing the metal-packed joints. The affected units were realigned by blocking, and the divers accomplished this assisted by the wrecking derricks. Before the new 12-ft. pipe length was lowered into position, a 5-ft. cast steel sleeve, 1¼ in. thick, was lowered down and slipped over one end of the pipe line. The function of this sleeve will be explained presently.

The bell of the replacement length was drawn

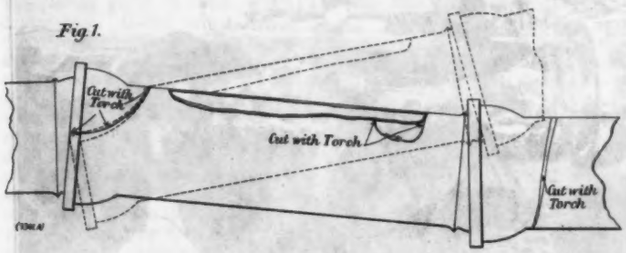

FIG. 1. FRACTURED PIPE.

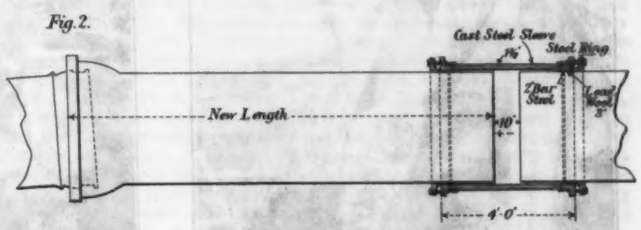

FIG. 2. NEW LENGTH INSERTED.

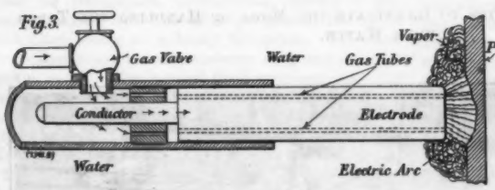

FIG. 3. THE CHAPMAN-KIRK BURNER.

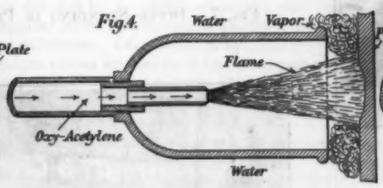

FIG. 4. GERMAN BURNER.

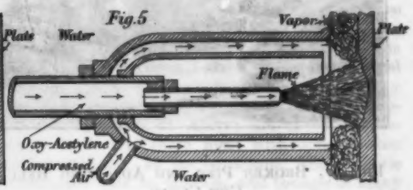

FIG. 5. FRENCH BURNER.

snugly into place by a harness consisting of two heavy steel collars—one gripping each contiguous unit—connected by long threaded through bolts. By screwing up the nuts on these bolts, the divers were able to bring the bell and the inserted spigot into proper relation, after which the joint was packed with lead wool, which was hammered home. The harness was allowed to remain. As shown in Fig. 2, the 12-ft. section could not bridge the entire gap in the pipe line as there was left an interval of about 10 in. between its spigot end and the neighbouring shortened pipe, and it was to close this breach that the 5-ft. cast steel sleeve was designed. The internal diameter of the sleeve was 1½ in. greater than that portion of the shortened section over which it had been slipped, and to make this difference uniform the annular ridges on the spigot end of the new pipe, which had been taken from stock, were machined off. When the sleeve had been shifted, so that it embraced equally the ends of both pipes, it was held at a common distance circumferentially by a series of 1-in. bolts. There were 12 of these bolts about 5 in. in from each lip of the sleeve, and this left two annular spaces ¾ in. wide and substantially 5 in. deep to receive the packing which was to complete the joints. These were made as follows: First, a split ring, formed of ½-in. iron, 2 in. wide, was inserted and seated against the inner projections of the bolts; next, against this solid backing, a caulking of lead wool was built up to a depth of 3 in.; and, finally, a cast steel gland was drawn against this packing by means of eight 1-in. threaded bolts. The gland serves to prevent the lead packing from working its way outward when the pipe is operating under a pressure due to a head of more than 200 ft.

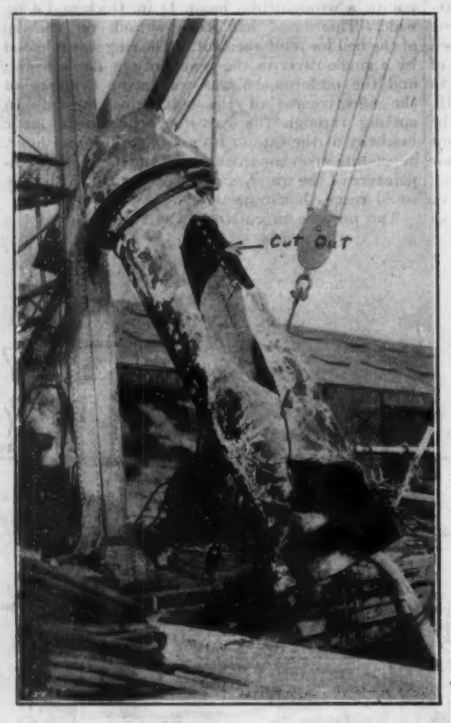

FIG. 6. BROKEN PIPE AND ADJOINING BELL, CUT CLEAR.

The Chapman-Kirk burner, which is protected by patents, is extremely simple in its design. This can be readily understood by reference to Fig. 3, while Figs. 4 and 5 respectively illustrate the basic features of the German and the French burners which, according to reports, have never advanced beyond the experimental stage. In the Chapman-Kirk burner low-voltage current is supplied to the carbon electrode by a conductor carried inside of the hose, which also conveys the cutting gas to the tip of the electrode. To bring the burner into action a diver holds the electrode about ¼ in. away from the metal to be dealt with, and arcing immediately takes place between the carbon and the nearby "ground." Current is not fed into the line until the diver signals his attendant that he is ready to begin cutting. The operator wears rubber gloves; and the electrode is wrapped with insulating material to check leakage and to add to the protection of the diver. A single carbon is good for approximately half an hour's service, and must then be renewed. By means of a valve, at the rear end of the apparatus, the diver is able to control the discharge of the gas to suit depth of submergence and the metal he is attacking. We give, in Figs. 7 and 8, reproductions of two photographs which were taken to illustrate the methods of using the burner. Fig. 7 shows a diver with burner standing in the pipe and explains how the torch was handled under water, while Fig. 8 shows a diver lying in the pipe and making the cut from within.

FIG. 7. DIVER STANDING IN PIPE TO ILLUSTRATE THE MODE OF HANDLING THE TORCH UNDER WATER.

FIG. 8. DIVER LYING IN THE PIPE AND CUTTING FROM WITHIN.

While the diver is not hampered by the heat or the glare of the torch, still the arc does tire the eyes, and, of course, it is impossible, because of the incandescence of the electrical discharge, for the worker to see the actual cutting. However, he can check up his progress, from time to time, by extinguishing the arc and feeling the cut with his gloved fingers. This is a sufficient guide for a man trained in the use of this very valuable gas-electric tool, which is the result of substantially four years of development and practical application in maritime salvage.

It will probably be of interest to mention some of the past performances of this invention.

In 1918, following the refloating of the liner St. Paul, the Merritt and Chapman Derrick and Wrecking Company was employed to raise the United States Army Transport America, which sank at her pier in Hoboken, New Jersey, on October 16 of that year. In preparing for pumping operations it was found necessary to cut drainage holes through a number of bulkheads; to sever the hinges on ice-box doors; and to cut a hole 20 in. in diameter into the shaft tunnel. The

submarine burner was of outstanding help in doing this work. In the same vessel openings were also made by drilling. By way of comparison, and as evidence of the superiority of the burner, it took two expert divers five days to drill a disc 10 in. in diameter out of a steel plate about ⅞ in. in thickness, while it required another diver, using the submarine burner, one day to cut a considerably larger hole through a plate ⅞ in. thick. The latter work was done at a depth of 61 ft.

On February 28, 1919, the S.S. Aquitania cut completely through the S.S. Lord Dufferin, which was anchored off Bedloes Island in New York Harbour, and a large section of the Lord Dufferin's stern dropped to the bottom of the Harbour. In dropping, this detached stern tore off the four lower tows of plating on the port side and left a portion of this plating turned outward and downward to a depth of 14 ft. below the vessel's keel. Dynamite could not be used to clear away this clinging wreckage because of the danger of further damaging the vessel. It was therefore decided to use the Chapman-Kirk underwater cutting torch; and in the course of eight days one diver succeeded in cutting and removing this 8-ton section of plating. The plating was ⅞ in. thick, and at the laps was double that. Owing to the action of the tides, the diver was able to remain under water only 4 hours or 5 hours per day. Some while later, when the S.S. La Perouse was loading at her pier on the North River, New York, it was discovered that a wire hawser was fouled between her propeller and the stern tube guard. A diver worked for several days endeavouring to remove the hawser with the ordinary facilities, but without success. Finally, the submarine torch was resorted to, and with it each turn of wire was cut through. Because of the speedy performance of the burner the steamer was able to sail on the date advertised.

Probably the most spectacular work of the burner was that done last December in connection with the salvage of the United States submarine S. 48, which sank off Bridgeport, Connecticut, during a submerged trial run. The after portion of the vessel had filled owing to a leaky Kingston. To refloat the submarine it was necessary to pump out her motor room. The normal deck entrance into that compartment was through a hatch, which was sealed with a heavy, ribbed, cast-steel cover locked from within before the submarine submerged. To release the hatch cover it was needful to get through the heavy steel casting. This was effectually done, at a depth of 70 ft., by cutting a hole in the centre of the cover with the subaqueous torch. The hatch was then opened, and divers entered the vessel and closed the bulkhead doors at the forward and after ends of the motor room. With this accomplished they fitted a temporary cover over the hatch. This cover was pierced centrally for a suction hose and carried a collar on each side for hose connections. The pipe leading from the upper side was joined to an air-driven submergible pump, which was secured near-by on the submarine's deck. The foregoing instances are mentioned to show some of the ways in which the under-water torch has been used in America since its inception. It should be evident that an apparatus of this kind has a wide field of possible application; and it undoubtedly will prove a potent aid to maritime salvors, to submarine engineers generally, and also to port authorities.

LITERATURE.

Hydraulics of Pipe Lines. By W. F. DURAND, Ph.D, Professor of Mechanical Engineering, Stanford University, California. London: Constable and Co., Limited. [Price 18*s.* net.]

THE congested condition of large cities has compelled the construction of huge aqueducts for the conveyance of potable water from long distances, and the science of hydraulics has acquired a greater importance than was contemplated in the days of smaller constructional work. The opportunities for the study of water in motion have been much enlarged, and its distribution over a wide area may present problems of difficulty, that demand careful attention. Further, the construction of irrigation works on a vast scale has necessitated the carriage of water over a vast variety of soils and surfaces, and provided much information concerning frictional effects, percolation, the formation of eddies and irregular turbulence. In other ways hydraulics finds wider and novel applications, and more decisive and authoritative guidance would be welcomed, but the results of theoretical deduction must be supplemented by experience. The conditions under which formulæ have been derived differ from those to which they are applied, or in other words, so many variables are encountered in actual practice that pure mathematical inferences fail to satisfy the problem. For example, in every work on hydraulics, an expression due to Chézy is given for the loss of head arising from friction in a conduit, in which occurs a well-known constant. Kutter has elaborated the formulæ for this constant, and invites our confidence by giving numerical coefficients to the fifth place of decimals. We imagine little use is made of such attempts at accuracy on constructional works. If Professor Durand does not actually discredit such formulæ, he fences them round with cautions that show he is disinclined to put implicit reliance on the variables, hydraulic gradient, roughness of pipe surface, or geometry of conduit. "With values *drawn from experience*, however, and representing these factors, the formulæ will give reliable results within the range of values covered by the experimental basis." The words that we have taken the liberty to italicise might imply, that theoretical hydraulics can be of little service in practice, and it would be very unfortunate if this idea were generally entertained, but it must be understood as the author strongly insists, that all empirical formulæ are affected by limitations, and that great danger attends the indiscriminate use of such formulæ, if their restrictions are unknown or neglected. The author is doing great service in placing this caution prominently before the student at the outset, for when such expressions appear in a standard work, supported by the authority of great names, the limitations are apt to be under-estimated and the formulæ applied under conditions to which they have little or no reference. Oftentimes discrepancies are revealed when values are deduced from independent authorities, and it may be with this view that Professor Durand has given data for comparing the results of various engineers as Darcy, Hamilton Smith, and others, together with some information derived from ship resistance experiments. The chapter ends with the discussion of some problems that arise in connection with the flow of water through a more or less complicated system of branches, under varying conditions of general distribution. The treatment is quite satisfactory and illustrates some points that occur in practice very fittingly.

The surge chamber, or device for supplying the deficiency or receiving the excess water required or rejected at an outlet with variable discharge, developing a retarding or accelerating head, which is impressed throughout the system, is discussed at some length. A variety of means for dealing with this important problem is put before the student, but it is disappointing to find the differential surge chamber very curtly dismissed. This is a peculiarly American contrivance in which a small reservoir is connected with a larger one by ports. A stand pipe in the small reservoir is connected to the line and to the penstock. The advantages claimed for the scheme have not, we believe, been universally admitted, but it may have acquired greater popularity of late, and in any case the theory would have been instructive and welcome. The author refers to a paper in which he discusses the problem of the surge chamber from a novel standpoint, which has the apparent advantage that the solution is direct and requires no trial and error approaches. His problem may be stated thus: Given a programme for the water, required the surge chamber that will produce it. This is the converse of the problem as usually stated, and applies when the dimensions and proportions of the chamber are left indeterminate, and any of the other variables entering into the equations may be fixed arbitrarily. The advantage is more apparent than real, for the form of the chamber may prove unsuitable from a structural point of view, though it satisfy the conditions of the hydraulic problem. In presence of computational difficulties and the number of variables, it is satisfying to find that the problem of the surge chamber can be treated by model experiments, through the application of the law of kinematic similitude. Similar plans have been so satisfactory in the case of aeroplane construction, when the flow of air past the model machine is under complete control, that similar methods applied to the flow of water should give informative results. Of the extent of practical application we have no information.

To pass from the operation of the surge chamber to the consideration of water ram or water hammer is natural and easy. Here, as elsewhere, the author is particularly happy in opening his subject by demonstrating the nature of the phenomena he is going to discuss. One is made to see and appreciate the effect of the successive states of water oscillating in column, giving rise to variations in the pressure condition of the same nature as an acoustic wave in air. The causes that develop a tendency for the water to separate and leave the upper end of the pipe, producing discontinuity and turbulence can be generally followed from the diagrams. Many exercises are given involving the gradual opening and closing of a valve under varying conditions, and the derivation of the necessary equations is rigorous. The graphs showing the history of pressure at various points in the pipe line, and under varying conditions after arrest of valve, opening and closing, will repay careful study and indicate the great variation that exists in practical cases. Apparently, these curves or many of them have been worked out accurately by strictly numerical methods, a work that must have involved much labour, by reason of the inherent complexity of the relations involved. Many attempts have been made to shorten the work by various writers, but they all involve the neglect of some factor that may attain importance. The author examines some of these proposed short cuts, not with any intention of criticising the work of their respective authors, but in order to contrast the results, admittedly approximate, with those derived from the complete theory, and to indicate the general conditions under which such approximations may be safely or appropriately employed. The development and formulæ of Allievi are the most frequently used, and these meet with some rather severe handling. In his equations, Allievi omits the influence due to friction, and though in many cases this may be permitted, yet naturally the omission grows in importance as the relation of the friction head to the total head increases. But the proposed approximate formulæ does not represent the equations, even shorn of this factor, and the assertion is made that the expression is frequently used by engineers, who neither understand its derivation or appreciate its limitations. Under conditions, which it is not necessary to repeat, "the use of the formula will lead to a result having but remote relation to that indicated by the more complete theory." The formulæ of Warren and of Joukovsky and others are analysed with practically the same result. The latter tacitly assumes that the rate of decrease of velocity from the start of the movement is uniform, but in no case will a uniform rate of valve closure determine a uniform rate of velocity decrease, and consequently where this assumption is made, "the development of the formula can be only imperfectly realised and in many cases the departure will be extreme."

In the following chapter is treated the general subject of stresses in pipe lines due to angles, bends, and joints, both when the distribution of pressure is determined by static conditions, and when under steady flow. Stresses in expansion joints come under review, and particular cases are treated with much care. The loads arising from balanced internal pressure must be carried by the pipe line element, subjected to the pressure, but those arising from unbalanced pressure can be carried by various external means of support or constraint. This leads to a valuable discussion on the influence of piers, ties, abutments, &c., on the development of stress in pipe lines, and on stresses in connections and fittings.

The main plan of the book, which aims at the

discussion of the hydraulic problems arising in connection with the transport of liquids through pipe lines, is departed from in presenting a general description of the more important structural elements of pipe line construction. This deviation from plan is probably dictated by a desire to equip the engineer student as completely as possible, and the information conveyed in this chapter, if not so comprehensive and thorough as the theoretical discussion, should be in the possession of the student. The materials of construction may not be numerous, apparently there is no mention of lead, but the methods of adapting them to the purposes they are to fulfil, the joints, that serve various duties, the caulking, the welding, and other operations, make a long tale, however much details may be suppressed. Writing from America, the wood-stave pipe naturally figures largely. The general method of construction is well known, and no very recent information is given concerning the progress of standardisation. The spacing of the supporting bands does not seem to be settled, and the thickness is decided by a compromise between the rate at which a thin band will perish by corrosion, and the difficulty of handling one of greater diameter than $\frac{1}{4}$ in. When the head reaches 200 ft., and the inside diameter of the pipe is 10 ft., very little wood can show, if both bearing value and tensile stress are to be satisfactorily sustained.

A final chapter is given on oil pipe lines, or a line intended for the transportation of crude or fuel petroleum oil in bulk from the wells to a distant station. The distinguishing feature is the increased value of the viscosity of oils as compared with that of water, and unfortunately viscosity and density introduce two new variables, to which values more or less arbitrary must be assigned. The relation between gravity and density may be ascertained but viscosity can hardly be regarded as simply a function of gravity and temperature. A number of complex constituents enter into the crude oil, and these profoundly influence the resultant viscosity. As a rule the viscosity increases with the density, and varies inversely with the temperature, but there are exceptions. Moreover, it is usual in order to reduce the viscosity of heavy oils to introduce machinery to raise the temperature. The heaters used are formed of closed steel cylinders, provided internally with headers and tubes through which the oil makes two passes on its way from the receiving tank to the pumps, while exhaust steam passes between the headers and tubes, raising the oil to a temperature of about 150 deg. F. Even if the pipes are under ground, as is usual, there must be a gradual fall in temperature with time, that makes the application of rigorous theory of little avail. We suspect that practical experience often supplants the deductions of analysis.

It only remains to congratulate the author on the production of a well-arranged, informing, treatise that should be welcomed by many students, and will increase the reputation of the Glasgow Text Books of Civil Engineering now publishing under the editorship of Mr. G. Moncur, B.Sc.

Technical Records of Explosives Supply. No. 2. *Manufacture of Trinitrotoluene.* Ministry of Munitions and Department of Scientific and Industrial Research, H.M. Stationery Office, Princes-street, S.W. 1. [Price 17s. 6d. net.]

WHEN the public is, at the present time, offered detailed technical information concerning the manufacture of trinitrotoluene (T.N.T.), the first question arising may be, whether the descriptions of plant and processes will be as precise and full as they might be, and whether important details are not withheld. Believers in the "last war" myth, if any be left, might indeed submit that such information comes too late and cannot have more than historical interest. There will be doubters, however, to whom such publications appear premature. But consistent doubters would condemn all publications of technical value and would thus bar progress. The public may rest assured that the Ministry of Munitions and the Department of Scientific and Industrial Research did not act hastily in making the results of their experience in the manufacture of high explosives available to the industries concerned; we have the definite statement, moreover, that in one or two instances definite information is withheld. On the other hand, nobody will doubt that the interest of reliable critical accounts of the methods applied and the experience gained, particularly in the Oldbury Factory and later in the huge Queen's Ferry Factory, will by no means be limited to the industry of explosives. Dr. W. Macnab, F.I.C., who takes the responsibility for compiling these reports, and his assistants are sure of the warm thanks of their colleagues in the chemical and engineering professions. Much of the information on dimensions, analyses and yields given in diagrams and tables, and many notes and hints would not be allowed to leave the office under ordinary conditions.

The general aspect of the T.N.T. problem at the outbreak of the war is now well understood. T.N.T. was not a service explosive; a little was made, chiefly as a by-product of the dye industry; there was hardly any technical literature on the subject; and the analogy of nitroglycerin manufacture did not prove very helpful. The strongest sulphuric acid, oleum, required in the manufacture, was very scarce, moreover, and a process of nitrating with strong sulphuric acid, not containing the anhydride SO_3, characteristic of oleum, was worked out at Woolwich. The sulphuric acid is, in the nitration, practically needed only for dehydration. When nitric acid HNO_3 acts on toluene $C_6H_5.CH_3$ a mono-nitrotoluene $NO_2.C_6H_4.CH_3$ (M.N.T.) is formed, and one molecule of water H_2O is split off; that water has to be absorbed by the sulphuric acid, which is therefore added to the nitric acid, as in other nitration processes. When both the acids are sufficiently strong the nitration proceeds at once to the trinitro product $(NO_2)_3 . C_6H_2 . CH_3$ (T.N.T.). This is the one-stage process which requires an excess of the strongest acid; the molecules of water which are liberated dilute the acid, and only a relatively small quantity of toluene can be dealt with in a vessel of a certain size. It is therefore preferable to work in two stages or in three stages, making first the M.N.T., mostly in separate works, and then the dinitro product D.N.T. Since the lower stages do not demand the strongest acid, the waste acid from the third stage can be used for the lower stages. At different stages mixtures of nitrobodies and toluene will be present which are distinguished, *e.g.*, as $\frac{1}{2}$ N.T., $1\frac{1}{2}$ N.T., 3 N.T., &c. The reactions are, of course, more complex, and depend much upon the temperatures used. The M.N.T., *e.g.*, is an excellent solvent for T.N.T. and acts as such (detoluator) whilst being itself more highly nitrated.

The processes underwent modifications as matters developed, and different methods remained in use in the same works. The two-stage process, in which toluene is nitrated first to $1\frac{1}{2}$ N.T. and then to T.N.T., the acid from the latter being fortified with nitric acid for the first stage, proved satisfactory as to yield, quality and convenience in working. In the very successful continuous process, adopted at Oldbury in 1917, strong sulphuric acid and M.N.T. are fed in at opposite ends of the plant to emerge as T.N.T. and spent acid at the other end, the nitric acid being added at intermediate stages. The plant used consists of pairs of cast-iron pots; one pot of each pair being agitated, while the other acts as a settling vessel from which the mixture travels on to the next agitator to meet stronger acid.

This process of manufacture, as well as the continuous washing process presently to be mentioned, was patented. In the removal of the acid, soda (useful in the case of nitroglycerin) has to be avoided lest highly sensitive compounds be formed. In the continuous washing process the fused T.N.T. —grade I melts at 80·2 deg. C.—meets clean water, of which only 600 gallons are wanted against 5,000 gallons by other processes. Hot water to which hypochlorite or sulphite of sodium are added, is also used, to remove organic impurities. The T.N.T. has to be filtered through baskets of phosphor-bronze gauze, dried (at 120 deg. C.), and finally to be pelleted or spread on cooled drums from which it is scraped off.

The original purification, by crystallisation from organic solvents (alcohol or benzene) and the subsequent distillation of the alcohol were by far the most dangerous operations, and the purification was hence, after several explosions, transferred to special stations in which either cold-alcohol washing or crystallisation with vacuum cooling was adopted. The station in which the last-named process was used was, however, destroyed by an explosion. Other solvents were then tried, and further a treatment with sulphuric acid, and centrifuging of the "toffee" (coarsely-crushed T.N.T.) with phenol. This latter process was attended with satisfactory results. In 1911 T.N.T. had been exempted from the Explosives Act; but that exemption was withdrawn in 1916. The risks of poisoning the workers became more serious than had been anticipated.

All these processes, their risks, successes and failures, and the plants, are very lucidly described in the volume (small octavo) of 116 pages illustrated by 63 figures comprising many folded sheets and photographs. The value of the publication lies, as we stated, in the descriptive detail. We are given plans of works and flow diagrams; we are told the dimensions and materials of the cocks and coils, the times and temperatures, the wear and tear, the suitable lubricants and the precautions to be observed; we can follow the losses on the quantities used, and the difficulties are by no means slurred over. The only thing we miss is an alphabetical index; but there is a good table of contents.

Analytical Mechanics for Engineers. By F. B. SEELY, M.S., Associate Professor of Theoretical and Applied Mechanics, and N. E. ENSIGN, A.B., B.S., University of Illinois. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 24s. net.]

AMERICAN teachers have of recent years produced some excellent treatises on mechanics that apparently were approved both by teachers and pupils alike, but judging from the views expressed at meetings held in the interests of engineering education, dissatisfaction with the results of teaching is rife and very openly expressed. The teaching of dynamics, an indispensable adjunct it must be admitted to the equipment of the scientific engineer, is unequivocally condemned and apparently on inadequate grounds. The C.G.S. system of units seems to be a source of annoyance, but no very grave charge can be founded on that score. The old complaint of insistance on artificial problems having no relation to the actual business of life is resuscitated, and possibly with more reason. But this grievance is disappearing, and in the recent books that we have noticed, as in this excellent treatise, emphasis is laid on the intention to apply the general principles of mechanics to concrete problems of practical value, and to construct the examples on common experience. Weightless pulleys do sometimes appear, and friction may be necessarily neglected, but those eccentric conundrums which served to display the ingenuity of the teacher, rather than to quicken the intelligence of the pupil, meet with scant favour. Murmuring dissatisfaction might be better justified if the old crude notions of force were swept away as an outworn "relic of animism," and the advocates of a newer and more philosophical conception allowed to introduce, possibly more exact, but certainly less simple, notions. Muscular exertion and sensations cannot be excluded from the working world, and we are glad to find that the authors have the temerity to hold that "the force" with which they are concerned in this book and in engineering practice is made known through the tension and compression of the muscles. Such an outspoken expression gives the assurance that actual mechanical construction will be illustrated and discussed, and that the physical, rather than the mathematical interpretation of the principles, will be emphasised.

The treatise is divided into three sections, statics, kinematics and kinetics. This is the order which has been followed time out of mind, and it has been said somewhat maliciously that one will find nothing in a work on mechanics which is not a century old. On seeing the references to D'Alembert's principle, one is reminded of this gibe, and also of its futility, for there can be no doubt the student enjoys an advantage in being brought into contact with the methods that recommended themselves to an old classic. In the first of these three sections, are given the usual fundamental propositions by the use of which the resultants of the various force systems

may be determined, and the conditions which the several systems must satisfy in order that the resultant of the forces should be zero. The algebraical and graphical methods of solution are both employed, and usually on the same problem. A large number of practical examples connected with the stresses in roof-trusses, cranes, cables, &c., are discussed in a very informative manner, and in the chapters on friction, and on moments of volume and of inertia, much care has been displayed.

In the section on kinematics we meet the problems related to the "motion of a particle," and under kinetics those to "rigid dynamics." The reason for such distinct separation is not very clear. A concession to the demands of engineering practice seems to be involved, for the general character of the problems is the same, and a resultant has to be found which causes a change in the motion of the body. Newton's laws are invoked in each case, and their limitation to the motion of a particle acted upon by a single force scarcely interferes with the determination of the motion of a body solicited by a system of forces. In deriving the equations of motion for the body, Newton's laws are treated with great respect, and are quoted more literally and more fully than is usual in modern works. The section on gyroscopic motion and gyroscopic couple appears to be rather too condensed to be of great service, but when treating of impulse and momentum, the authors return to this subject. On the other hand, the discussion of Rite's inertia governor is very fully elaborated. The collection of examples, moreover, seems to be carefully made and many of these are completely solved. The work is written apparently in the interests of both teachers and students, to the one it should give direction, to the other enlightenment.

Patents and Chemical Research. By HAROLD E. POTTS, M.Sc. Liverpool: The University Press. [Price 8s. 6d. net.]

THIS book, on a rather unusual subject, is written by a member of a well-known provincial firm of patent agents. It is difficult to know to whom it is addressed, but probably it is more especially intended to be read by chemical research workers, particularly directors of research, and not by lawyers or professional people dealing with patents, though in some places it shows a tendency to teach these how specifications should be interpreted or drafted. Whether there are enough research workers or directors to justify publication is a matter which doubtless the publishers themselves have already considered. The book is certainly of considerable interest, and there is a great deal of pleasure to be obtained from its perusal, for one reason because the writer being a chemist, the involved chemical terms employed are correctly used, and not misspelled. The book is singularly free from typographical errors. Although the references to reported patent cases have not all been checked, they appear to be accurate, and this is a very great point in such a book.

There is a clerical error at the top of page 85; namely, the word "effect" should read "affect," but this is not likely to be misleading.

Seeing that the publication is mainly directed to other than legal people, a caution should be added with reference to the suggestion contained in the Preface and in two other places, that generous interpretation should be given by the Courts. The intent of the references as a whole is that chemical specifications should be generously construed. A chemical specification, if clearly drafted, should not be construed any differently from any other document. British judges are very fair-minded, as is known the world over, and being fair-minded they do not seek to construe a document of this kind on the one hand in favour of the chemist patentee, nor on the other hand in favour of the public, for this is a case in which what is given in favour of the chemist is against the public, if it be the fact that the chemist has not properly described or properly claimed what is to be covered. The whole point that the judges seek to ascertain is what is the true construction of the specification.

The book as a whole is based on lectures delivered before the British Association at Liverpool, and contains an additional chapter relating to patents in other countries. This is probably the most important chapter. The others relate to patents as an element of business policy, patent procedure, the obtaining of maximum protection for an invention, the accuracy of experimental data and theory required in patent specifications, the validity of patents, and the definition of an invention.

The first chapter relating to business policy is very good, and might well be considered by large manufacturers. In this there is a reference to the effect of secret prior user, and the suggestion is made that if a secret user can prove that he has actually used an invention on a commercial scale in England before the date of the patent, he will be able to upset a rival patent. The law on secret user is by no means clear, and there are no modern cases which properly elucidate it, but it might be well to caution readers of the book here that if the secret user has been abandoned, it may not upset the patent. The Statute of Monopolies contains the words "which others at the time of making 'the grant' shall not use." This probably excludes abandoned secret users.

On page 29 it is said the Patent Office usually does not raise the objection that the specification does not deal with a manner of manufacture. This is against the experience of many inventors at the present day. Later in the book there is a point made that many inventors do not fully appreciate, namely, that infringement and anticipation are entirely different issues. It is well known to all legal people dealing with patents, but the writer here correctly emphasises it. There is one point on the drafting of specifications that should be observed. Mr. Potts takes considerable care in showing how one should indicate the possibility of using analagous bodies to those specifically mentioned in the specification and covering them, but he does not point out the simplest method, namely, by referring to them specifically.

In discussing the effect of errors in the theory of an invention on pages 92–93, a contrast is well introduced between the kind of error that invalidates and that which does not seriously affect validity. A rather novel heading is to be found on page 134, namely, that "artifices" are often patentable. This is correct, and the subject might be studied with advantage.

In discussing the half-watt lamp case, the writer tends again to seek for generous treatment in favour of the patentee; for, commenting on the judgment in the first court and the Court of Appeal against the patent, he says, "while deliberate ambiguity is to be deprecated, I suggest with respect that it is to be hoped that objections of this kind (that is, insufficient definition) will not be pressed too far against valuable patents in the future." He will be pleased to know that the House of Lords have now upheld the patent; not on the ground that indefiniteness is permissible, but on the ground that the definition in this particular case was sufficient. A final word may be added on the index, namely, that it is adequate, well sub-divided, and appears to be accurate.

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FOREIGN LOANS AND AMERICAN INDUSTRIES.—We read in *The Iron Age*, New York, that the National Foreign Trade Council has sent a letter to other trade organisations and chambers of commerce throughout the United States requesting their co-operation in a plan which, it believes, will assist in reducing unemployment in the country, by providing that a part at least of the proceeds of foreign loans floated in America shall be spent for American products. The council urges American investors to insist that the underwriters of foreign loans shall require the inclusion in the loan agreement, wherever practicable, of a stipulation covering such use of loan proceeds. The council points out that it is the settled practice of British and other European bankers to require such a stipulation as a condition precedent to making a foreign loan, and adds that the effect of such a practice in providing employment for the industries of the country furnishing the money is obvious. The National Foreign Trade Council includes in its membership the United States Steel Corporation, Standard Oil Company, Pullman Company, Consolidated Steel Corporation, Westinghouse Electric Company, Hupp Motor Car Company, General Electric Company, Foundation Company, and American Radiator Company.

STRESSES IN THE FIREBOX CROWN STAYS OF LOCOMOTIVE BOILERS.

THE support of the fire-box crown sheet by means of staybolts directly connected to shell plating of cylindrical form entails a lower expenditure on materials and workmanship than that necessitated by any alternative method of construction. In many cases considerations of lower first cost and less deadweight may form a sufficient inducement to warrant a preference for this form of construction, there is also the additional advantage that the cylindrical shape of the upper portion of the fire-box shell renders it easier to provide a satisfactory outlook for the driver, when the height of the cab is limited by a restricted loading gauge.

Practical experience appears to indicate that the repairs and renewals of radially stayed fire-boxes are unduly high—many of the users of this type of boiler have adopted expedients with a view to reducing the frequency of breakage of the stays and to eliminating the formation of longitudinal cracks.

American builders usually fit spherical seatings between the external heads of the stays and the shell plating, in order to eliminate bending stresses at the outer ends of the stays. In Canada, some ten years ago, the practice was introduced of stiffening the shoulders of the shell plate by means of internal angle brackets, which were connected by means of transverse ties passing clear of the fire-box crown sheet between the rows of radial stays. Certain British railways have adopted the practice of fitting horizontal transverse stay bolts, and Continental designers invariably make similar provision for direct horizontal connections from side to side.

Radial stay bolts provide for the direct balancing of the steam pressure acting vertically downwards on the crown sheet against the vertical components of the internal pressures around the upper part of the shell plating, but the equilibrium of the horizontal components involves indirect stresses of some complexity. Investigation of these stresses does not appear to have been published hitherto.

Relative Stiffness.—One half of a cross-section through the upper part of a typical radially stayed fire-box is indicated by Fig. 1. There are 12 radial crown stays in each transverse row, about 4½ in. apart between centres where they enter the crown sheet, whilst the longitudinal pitch of the rows of stays is about 4 in. The staybolts are mutually divergent, and are assumed to enter the shell plate through holes equally spaced at a pitch which subtends an angle of 10 deg. at the centre line. The downward pressure on the fire-box balances the upward components of the pressure acting on the arc of the shell plating over an angle of 60 deg. at each side of the vertical centre line. The object of this investigation is to examine the nature of the stresses involved by the equilibrium of the horizontal components and to suggest means for reducing their intensity, if they should be found excessive.

It is first necessary to determine the relative stiffness of the component parts of the structure. Each transverse section is made up of 12 components, one of which is shown diagrammatically by Fig. 2. The line A B represents a staybolt of 1 in. mean diameter, C D is a portion of the arc of the shell plating, the length of the arc being $r\theta$, where r is the radius of the barrel and θ the circular measure of an angle of 10 deg. The plate is assumed to be of steel, 0·7 in. thick, and to extend for a length of 4 in. in a direction perpendicular to the plane of the figure. The line E F is a portion of the fire-box crown sheet approximately 4·23 in. by 4 in. square, it is assumed to be of copper, 0·625 in. thick, and to have a modulus of elasticity equal to 0·6 of that of steel.

The stiffness of each member is directly proportional to the product of its moment of inertia, and its modulus of elasticity, *i.e.* :—

For the shell plate	... ...	0·1143 E.
For the staybolt	... ...	0·049 E.
For the firebox plate	0·0814 × 0.6 E. =	0·0488 E.

The relative stiffness of the shell plate is 2·33 times that of the staybolt and the rigidity of the latter is practically equal to that of the copper fire-box plate. If the fire-box were made of steel 0·35 in. thick, its stiffness would be represented by 0·01429 E, or about 0·29 of that of the staybolt.

Points of Contraflexure.—When the component member shown by Fig. 2 is subjected to a shear, it will tend to assume the form which is indicated to an exaggerated scale by the broken lines. There will be a point of contraflexure somewhere near the middle of the length of the staybolt and similar points at the extremity of each section of plating.

Fig.1.

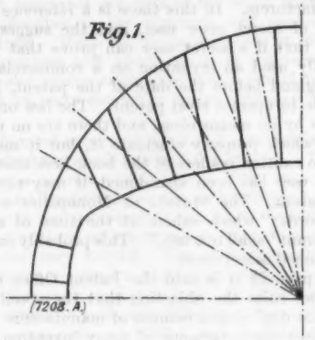
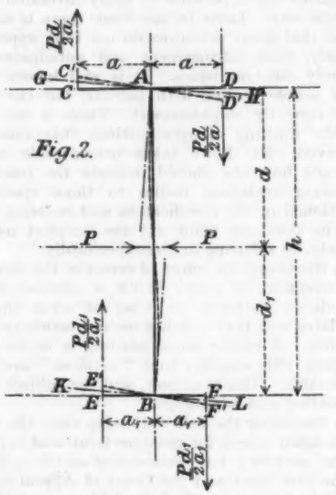


Fig.2.



¼ Now when G H and K L are the tangents to the curves of the plates at A and B respectively, the slope at C¹ with respect to G H is

$$\frac{P\,d}{2\,a\,E\,I}\,\frac{a^2}{2}$$

the deflection at C¹ with respect to G H is

$$\frac{P\,d}{2\,a\,E\,I}\,\frac{a^3}{3}$$

Now the slope of the stay at its point of contraflexure with respect to the tangent to its curve at A is

$$\frac{P}{E\,I_s}\,\frac{d^2}{2}$$

and its deflection with respect to the tangent at A is

$$\frac{P}{E\,I_s}\,\frac{d^3}{3}$$

The rise of G above C is

$$\frac{P}{E\,I_s}\,\frac{a\,d^2}{3}$$

The total rise of C¹ above D¹ is

$$\frac{2\,P}{E\,I_s}\,\frac{a\,d^2}{3}+\frac{P}{E\,I}\,\frac{a^2\,d}{3}$$

and since $I = 2{\cdot}33\ I_s$, the deflection becomes

$$\frac{P}{E\,I_s}\left(\frac{(2\,a\,d^2}{3}+\frac{a^2\,d)}{6{\cdot}99}\right)=\frac{P}{E\,I_s}\,\frac{4{\cdot}66\,a\,d^2+a^2\,d}{6{\cdot}99}$$

The deflection at the lower end is similarly

$$\frac{P}{E\,I_s}\,\frac{2\,a_1\,d_1^2+a_1^2\,d_1}{3}$$

assuming that the length of the staybolt is unchanged and writing $n\,a$ for a, and $h-d$ for d, equating the deflections we have :

$$2\,a\,d^2+\frac{a^2\,d}{2{\cdot}33}=2\,n\,a\,(h-d)^2+n^2\,a^2\,(h-d),$$

or

$$2a\,(1-n)\,d^2+\left(\frac{a^2}{2{\cdot}33}+4\,n\,a\,h+n^2\,a^2\right)d=2\,n\,a\,h^2+n^2\,a^2\,h.$$

When $a = 2{\cdot}75$ in. and $n = 0{\cdot}77$ as in Fig. 1.

$$5{\cdot}5\times{\cdot}23\,d^2+(3{\cdot}24+4{\cdot}48+8{\cdot}46\,h)\,d=4{\cdot}23h^2+4{\cdot}48\,h.$$
$$d^2+(6{\cdot}1+6{\cdot}68h)\,d=3{\cdot}34\,h^2+3{\cdot}54h$$

Substituting $h = 8$ in., its value in the outer row of staybolts, $d^2+59{\cdot}54\,d=242{\cdot}08$:

$$d^2+59{\cdot}54d+29{\cdot}77^2=886{\cdot}25+242{\cdot}08=1128{\cdot}33$$
$$d+29{\cdot}77=33{\cdot}59$$
$$d=3{\cdot}82$$

The point of contraflexure is therefore very near the mid-length of this stay.

The vertical shear on the upper plate is

$$\frac{P\,d}{2\,a}={\cdot}7\ P$$

and on the lower plate

$$\frac{P\,d_1}{2\,n\,a}={\cdot}94\ P$$

and its total intensity is

$$1{\cdot}64\ P$$

That is to say, the horizontal shear at the point of contraflexure in the staybolt is about 0·6 of the vertical shear transmitted across the element.

By successive substitutions of the value of h for each stay, the points of contraflexure and relative values of the shearing forces are found. They are summarised in the following table :—

Stay No.	h.	d.	d_1	$\frac{P\,d}{2\,a}$	$\frac{P\,d_1}{2\,n\,a}$	P in Terms of Shear S.
	in.	in.	in.			
5·6	8·0	3·82	4·18	0·7 P	0·94 P	0·61 S
7·8	10·5	5·03	5·47	0·915 P	1·23 P	0·46 S
9·10	12·5	5·93	6·57	1·08 P	1·51 P	0·38 S
11·12	14·0	6·62	7·38	1·2 P	1·66 P	0·35 S
13·14	15·0	7·09	7·91	1·29 P	1·77 P	0·32 S
15·16	15·5	7·33	8·17	1·33 P	1·83 P	0·31 S

The stresses and deflections under the shears produced by the given loading may then be determined. Having ascertained the position of the points of contraflexure the intensity of the bending stresses on the stays and plates may, however, be directly ascertained in the following manner.

Shearing Forces.—Let p represent the internal pressure acting on each strip of shell plating having a width of 1 in. measured circumferentially, and a length of 4 in. equal to the longitudinal pitch of the rows of stays. That is to say, let p be four times the working pressure in pounds per square inch.

If the whole of the cross-section as shown by Fig. 1 is assumed to be filled with steam, each strip of shell plating 4 in. long will support a tension of $p\,r$ lb., when r is the radius of the boiler. If, however, the steam pressure is removed from the area representing the interior of the fire-box a load of $4{\cdot}23\ p$ lb. will be applied to each stay, and the construction generally will be subject to a bending moment producing tensions in the fire-box crown and compressions in the shell plate, which latter will counteract the greater part of the tension which would otherwise exist therein.

The deflection under the bending moment is negligible by comparison with that due to the transmission of the shearing forces. The intensity of the latter may be ascertained by the construction of a reciprocal stress diagram as in Figs. 3 and 4. The structure is assumed to be completely triangulated by means of diagonal members, the load on each of which is ascertained by the usual method of procedure, when the loading at each panel point is taken as that due to a pressure of 175 lb. per square inch multiplied by the area of plating supported by each stay.

The tension in each diagonal multiplied by the cosine of the angle a between its line of action and the centre line of the adjacent staybolt gives the transverse shearing force parallel to the centre line of the stay, the force P is ascertained in terms of the shear, this when multiplied by the length of the stay from plate to point of contraflexure gives the bending moment, from which the extreme fibre stress is determined by division by 0·098,

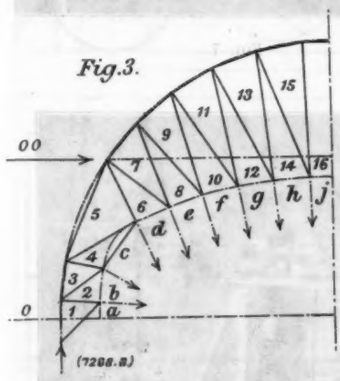
the moment of resistance corresponding to a diameter of 1 in.

The results for the upper ends of the stays are given in the following table :—

Diagonal No.	a	Lb. Tension × cos a = Shear Parallel to Staybolt.	P = k 8	Moment P × d.	Stress = M × 1 / 0·098
	deg.				
6·7	28	2,450 × 0·883 = 2,163	995	5,005	52,802
8·9	22	2,180 × 0·927 = 2,020	767	4,548	47,981
10·11	19	1,500 × 0·945 = 1,417	496	3,283	34,635
12·13	17	1,100 × 0·956 = 1,051	336	2,332	25,135
14·15	16	600 × 0·961 = 576	178	1,304	13,757

The tensional stresses due to bending are increased by the stress of about 3,800 lb. due to direct tension. The upper row of water-space stays and the three outer rows of roof staybolts at each side are stressed beyond the elastic limit of the materials usually employed for such stays. The deflections are no longer proportional to the stresses, and they are not susceptible to exact definition. Though much useful and economical service is given by structures which are occasionally subject to stresses beyond the region of proportionality, it is not probable that there is a final economy in the habitual imposition of such stresses, as the frequency of repairs and renewals is necessarily high.

Flexible Stays.—When the stays are fitted with external ball heads bearing in spherical seatings, the bending moments at the landings in the shell plate are eliminated; there is no intermediate point of contraflexure in the stay—the intensity of the shearing force is unaltered, but the leverage with which it acts on the point of landing in the fire-box roof is increased from d_1 to h. The practical advantage of the spherical head when used with horizontal water-space stays lies in the elimination of reverse bending when one end is displaced relatively to the other by differential expansion of the plates. The bending stress induced by a given movement is one-half of that of a stay of the same diameter, but having rigid fixation at both ends.



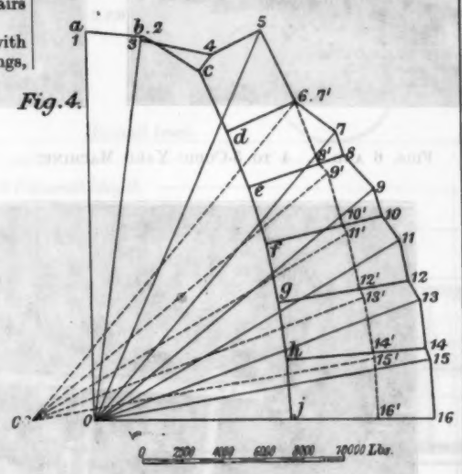
The adoption of a ball joint at the upper end of the roof staybolt will consequently increase the moment at the lower end of the stay. The shell plating will deflect more readily towards an elliptical form and the reaction of the stays will be limited by the support of a portion of the load by direct compressive stress on the fire-box crown sheet reducing the intensity of the shearing forces. Practical experience alone can demonstrate the effect of the arrangement in prolonging the life of the parts, as direct methods of calculation are inapplicable to structures of this nature where the elastic limit of the material is exceeded.

In actual practice it is not feasible to place a definite limit on the proportion of the load which will be supported by direct compression in the roof sheet. The primary object of the staying is to eliminate such compression stress, for although the curve of the crown sheet may be formed exactly to the line of equilibrium under the applied loads, it is not practicable to provide effective abutments for receiving the thrust. The shoulders of the box will exhibit signs of distress, and failure will eventually take place through the formation of longitudinal grooves or pockets.

The staybolts may, however, be relieved of all stress due to the transmission of shearing forces whilst they effectively support the whole of the load on the roof, if the outer shell plate is formed to a suitable profile, the actual outline of which may be modified by changing the inclination at which the individual stays meet the plating. The profile, however, cannot be made to approximate closely to the original semi-circular form without introducing secondary bending stresses so long as the staybolts are effective in supporting the roof load.

High secondary stresses are also developed in the cases of alternative methods of support, whenever any portion of the roof load is supported by direct connections to a semi-circular shell plate.

Framing made up of quadrilateral components cannot be rectified by the process of increasing the strength of those parts which indicate weakness under the application of bending moments, because an increase of the dimension in one part is liable to cause a still greater addition to the relative stiffness, involving a redistribution of the moments, increasing them on the strengthened part, and reducing them on the parts which originally appeared to be of ample strength.



Transverse Stays.—If a cross-tie is fitted at the level of the heads of the outer row of roof staybolts, as shown by the dot and dash line in Fig. 3, and if this stay can exert a tension of about 3,200 lb., it will modify the shearing forces as indicated by the broken lines and accented figures in Fig. 4. The bending moment on the outer stays will be eliminated, and those on the remainder of the stays will be reduced to insignificant amounts. In this position the cross-tie does not reduce the moment on the upper rows of water-space stays, but the modifications necessary to deal with these also are perhaps sufficiently obvious.

The additions to the weight and cost necessary to eliminate excessive secondary stresses in the radially-stayed fire-box are not of serious moment. Alternative methods of construction will still be heavier and more expensive whilst they also, as usually designed, involve undesirably high stresses. In the Belpaire type of box there is frequently an excess of flat area in the external shell, the support of which imposes bending moments on the inner box, particularly near the middle of the upper and of the lateral flanges of the tube plate. These lead to horizontal cracks across the bridges of the top tube holes, and to vertical cracks between the outer tube holes at each side.

Water-Space Stays.—When the width of the water spaces is increased from the foundation ring upwards, modifications of the curvature of the flanges are necessary if secondary bending stresses are to be avoided. In the absence of such precautions the stays next the corners are liable to breakage, and the bending moments will encourage the formation of vertical grooves in the flanges.

Mechanical causes are also responsible for the breakage of stays near the middle of the side plates in the neighbourhood of the expansion brackets. The reason being that the frame plates at this point are in some cases stayed only by the fit of the bracket in the guide. In the case of an engine having main frames 1¼ in. thick with complete horizontal bracing except for a length of, say, 100 in. for accommodating the fire-box, the transmission of a lateral force of sufficient intensity to impose a stress of 5 tons per square inch would involve a deflection of about 1 in. between the foot-plate casting and the next cross bar, if the movement of the framing were not opposed by the stiffness of the fire-box.

The cost of maintenance and of renewal of locomotive fire-boxes is necessarily considerable by reason of the high and variable temperatures incidental to the conditions of working, but there is reason to believe that revisions of design in the direction of the elimination of secondary stresses would result in economies of considerable magnitude.

THE BUILDING TRADES EXHIBITION AT OLYMPIA.

(*Concluded from page* 498.)

IN concluding our notices of this exhibition (which closed yesterday) we may first refer to the extensive display of concrete machinery, tar macadam plant, steel piling and other of their specialities made by the Ransome Machinery Company (1920), Limited, of 14 to 16, Grosvenor Gardens, S.W. 1. The concrete machinery shown included an example of Messrs. Ransomes' new "Aero" mixer, of which examples are illustrated in Figs. 6 to 15, on pages 516 and 517. This machine represents quite a new departure in concrete machines and gives an intimacy of admixture of cement with the aggregate which one may well believe it is impossible to get in the more normal type of machine. This intimacy of admixture obviously results in a very uniform and strong concrete, and this effect is in practice so marked that a concrete of equal quality to normal can be obtained with a lower proportion of cement than is necessary with ordinary mixing. Many users will, of course, be prejudiced against any such idea as this and will hold that good concrete must contain the recognised proportion of cement. In a matter of this kind it takes time for any new method to make its way, but as this lower cement proportion is in no way an inherent feature of the "Aero" mixer, doubt about the validity of tampering with recognised proportions need not delay employment of the machine. No user is likely to quarrel with a stronger and more uniform type of concrete than usual made from his standard proportions, nor yet is he likely to quarrel with the labour saving which the machine allows.

The "Aero" mixer, which is made in two sizes, both of which are illustrated in Figs. 6 to 15, pages 516 and 517, introduces an entirely new principle into concrete mixers. This is the use of a cement "mist" through which the moistened stone and sand pass, and by means of which each particle becomes entirely and evenly coated with a layer of cement. This naturally results in a very uniform spreading of cement throughout the mass of the resulting concrete, and leads to the evenness of quality and improved strength to which we have already referred. The "mist" is formed by blowing the cement into the mixing drum into which the aggregate thoroughly wetted, but without any surplus free water, is introduced. The action will best be understood by following the main parts of a machine in detail. For this purpose we may proceed to a description of the larger model which is illustrated in Figs. 8 to 12. This has a capacity of 10 cub. yards to 15 cub. yards an hour. The smaller model, which is illustrated in Figs. 6 and 7 and 13 to 15, has a capacity of 4 cub. yards to 5 cub. yards an hour. The essential features of the two machines are similar, and points of detail difference in the smaller we will indicate later.

Referring to Figs. 8 to 12, it will be seen that the machine is portable, being mounted on road wheels and that it is built up on a steel frame of rolled sections. A main driving shaft with fast and loose belt pulleys is carried below the main frame at about the centre of the machine. The power required is small, being only about 4 b.h.p.,

"AERO" CONCRETE MIXERS.

CONSTRUCTED BY THE RANSOME MACHINERY COMPANY (1920), LIMITED, ENGINEERS, LONDON.

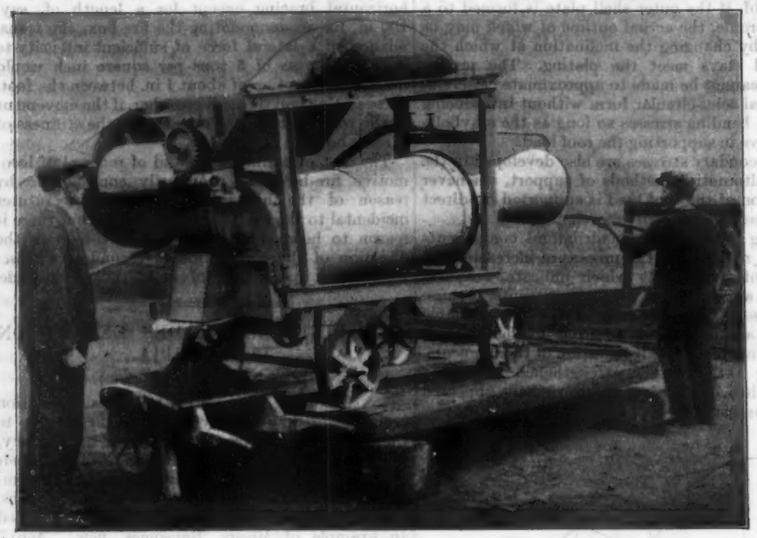


FIG. 6.

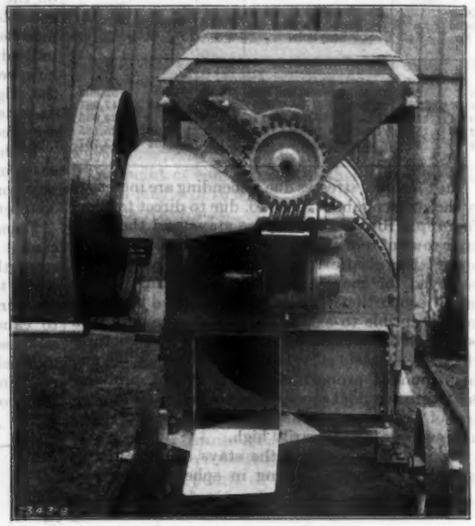


FIG. 7.

FIGS. 6 AND 7. 4 TO 5-CUBIC YARD MACHINE.

and the main driving shaft runs at 300 r.p.m. As will be seen from Figs. 9 and 10, the main shaft drives a second motion shaft through spur gearing. This second motion shaft drives a bucket elevator through a Renold chain, and drives the mixing drum through a pair of bevel gears. There is a steel plate hopper situated at the end of the machine which is shown to the left in Figs. 9 and 10, and into this hopper the sand and stone are loaded. The hopper is divided into two parts by a partition down the centre, one-half being used for stone and the other for sand. Two sliding doors at the bottom, regulated by hand levers, enable the correct quantity of sand and stone to pass continuously to produce concrete of any desired proportions. Below these sliding doors there is a shaker tray which is operated by the bevel-driven shaft which connects with the main drive and which can be seen in Figs. 9 and 10. This shaker tray receives sand and stone from the hoppers, the approximate proportions being regulated by the lever controlled sliding doors, and the action of the shaker intermingles the stone and sand in such a way that the sand accurately fills the voids between whatever sized stones are passing at any moment. A little surplus sand may be used if desired without affecting the quality of the concrete produced.

From the shaker tray the mixture passes to the bucket elevator, and is delivered through a chute into the mixing drum. It is in the course of passing down this chute that the water is added to the mixture. A water spray pipe is fixed at A in Fig. 9, and as the stones and sand fall they pass through a fine spray, which also falls on the mixture of sand and stones at the bottom of the chute as they are about to pass into the cylindrical screen inside the revolving drum. This method ensures that each particle is completely wetted all over and at the same time ensures that no surplus water is added. The water supply is regulated by two taps, one of which is set for the correct delivery and is not afterwards touched, the other being used for shutting down or starting-up. The mixing drum is rotated by means of a bevel driven from the main shaft and a spur-drive on to the toothed ring mounted on the end of the drum itself. The arrangement is clearly shown in Fig. 10.

As will be seen a cylindrical screen is fixed inside the drum and revolves with it. This screen is made with various-sized holes which separate the fine, medium and coarse portions of the damp aggregate so that the various particles fall from the screen into the drum separated from each other.

FIG. 8. 10 TO 15-CUBIC YARD MACHINE.

It is in this separated condition that the particles meet the cement "mist" to which reference has already been made, and it will be clear that the arrangement will result in each particle of sand or stone becoming evenly coated al over with cement, with the excellent results already referred to. Fixed to the inside of the drum there are a series of steel angles which act as lifting vanes and carry the material round while it is still being sprayed with cement. Above the discharge end of the drum there is a cement hopper, the top of which is formed with a wire-mesh sieve which prevents hard lumps or pieces of sacking from getting into the machine. The cement requires no hand gauging, and is simply emptied into the hopper. Inside the hopper there are two spiral conveyors, driven by chain from the top end of the elevator. These feed the cement forward through openings in a cast-iron distribution box. Slides fitted with indicators control the size of these openings so that the exact amount of cement passing into the mixing drum may be regulated. The cement is blown into the mixing drum by means of a fan fitted with six spring steel blades and running at 1,600 r.p.m. It is indicated at B in Fig. 9, and is driven by chain and enclosed gearing. When it is running

"AERO" CONCRETE MIXERS.

CONSTRUCTED BY THE RANSOME MACHINERY COMPANY (1920), LIMITED, ENGINEERS, LONDON.

Fig. 9.

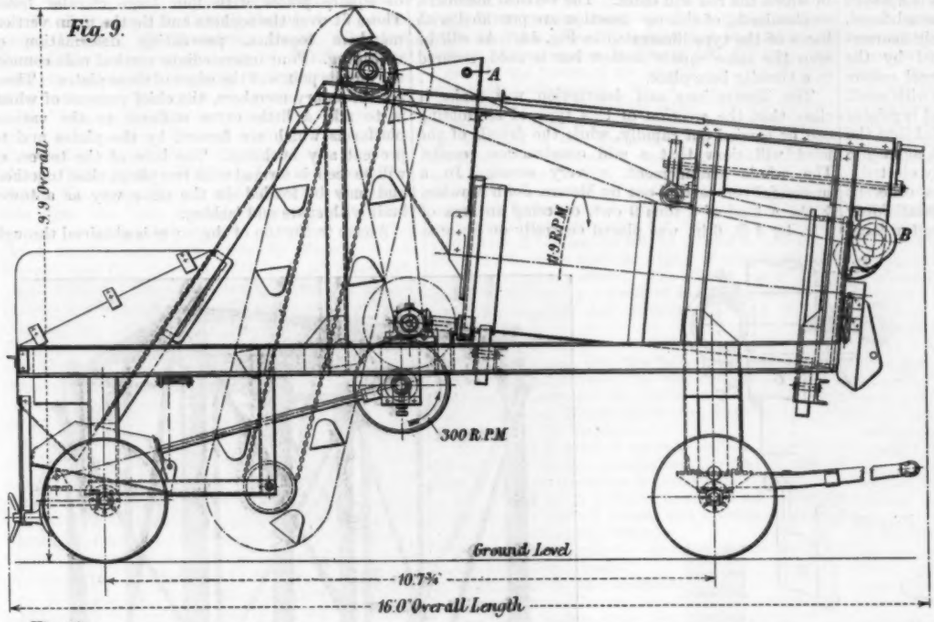


Fig. 11.

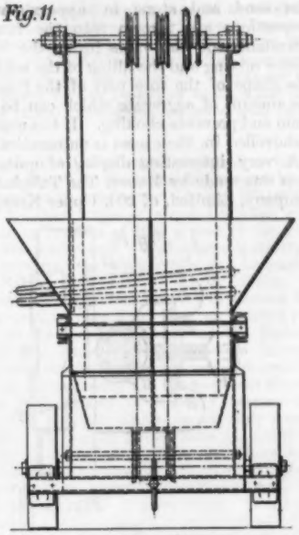


Fig. 10.

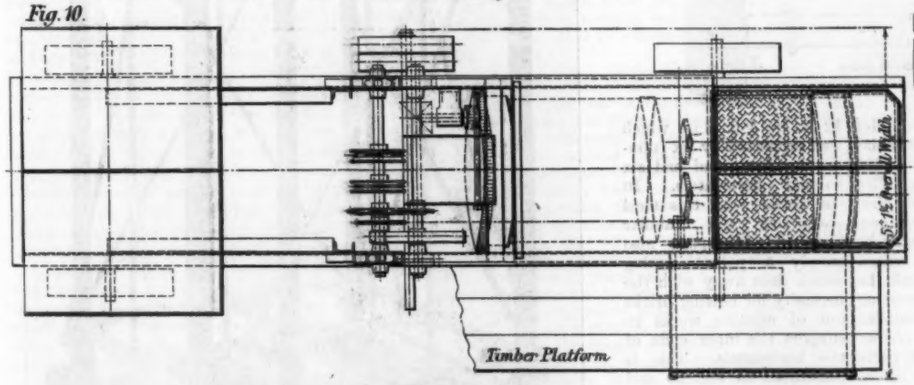


Fig. 12.

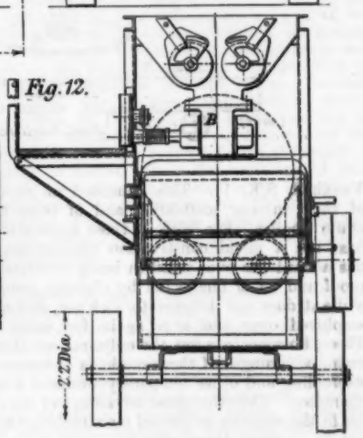


Fig. 13.

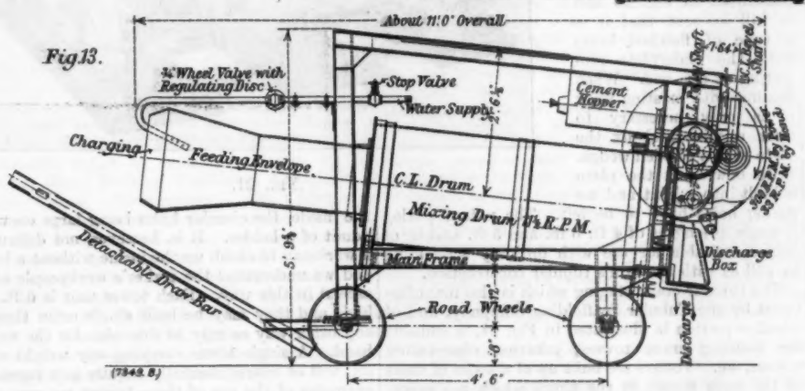


Fig. 14.

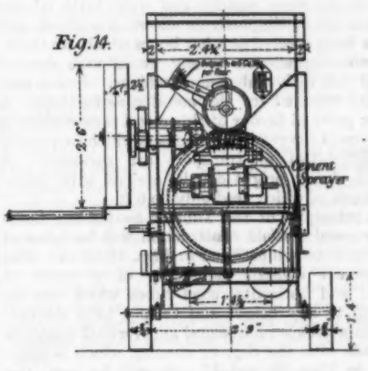
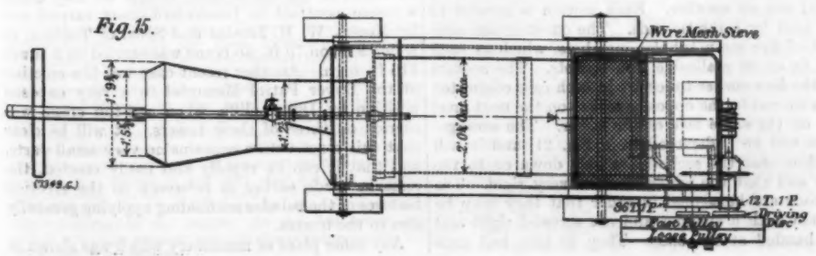


Fig. 15.

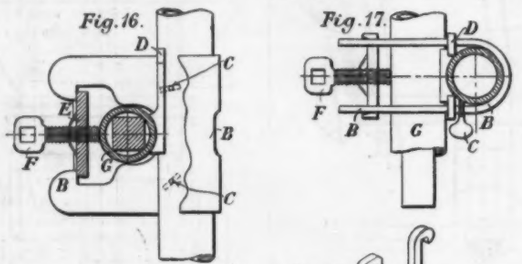


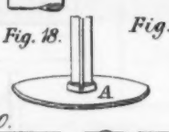
the interior of the drum is filled with a dense smoke-like cloud of cement. The machine discharges through a box which can be seen in the figures. It, of course, operates continuously and not in batches, but may be instantly stopped or started at any time.

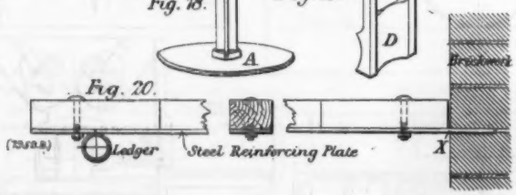
As we have already said, the general action of the smaller machine, shown in Figs. 6 and 7 and 13 to 15, is the same as that of the larger. In order to reduce the size and cost of this smaller model a special feeding funnel has, however, been adopted. The cement blower, mixing drum and discharge end of the machine generally are the same

as already described. The revolving feeder funnel, however, takes the place of the sand and stone hoppers, the shaker tray and the elevator. This funnel is mounted on and revolves with the drum. The aggregate is fed directly into it and is sprayed from the water pipe which enters the funnel front. The sand and stone in approximately correct proportions are thrown into the funnel by the attendant, and the vanes inside the funnel ensure proper mixing and the filling of the voids with sand. The shape of the fore part of the funnel regulates the amount of aggregate which can be fed into the drum and prevents choking. If too much aggregate is shovelled in, the excess is automatically ejected.

A very interesting display of quite a different class was made by Messrs. The Tubular Scaffolding Company, Limited, of 200, Upper Kennington-lane, Vauxhall, S.E. 11. This consisted of an exhibit of their tubular scaffolding and of their tubular crane staging. For both of these applications the firm use a metal construction throughout. This has advantages over wood in being absolutely fireproof and being unaffected by climatic conditions, while it does not deteriorate with use, and may be employed over and over again for many years. These, however, are not the only, nor we think the main, advantages of these methods of constructing scaffolding and other temporary works of a similar character. The other great advantage of the system lies in the methods employed for attaching the parts one to another, these allowing joints to be made, or unmade, very rapidly and with little labour. This feature of the methods allows of scaffolds and towers being erected in a few hours which, we think, it is no exaggeration to say would take days if carried out with timber and lashings. Fewer men also are required for the metal constructions. A further point in favour of this metal construction is that none of the very long members which frequently add difficulties to transport are necessary. A scaffold of any height can be erected with tubes, the longest of which need only be 6 ft.







The principles of the Tubular Scaffolding Company's metal scaffold construction will be followed from the details illustrated in Figs. 16 to 19. The arrangement consists essentially of a series of vertical and horizontal steel tubes which can be built up to any height and to any form desired. The joints between horizontal and vertical members are made with the clip, or coupler, which is illustrated in Figs. 16 and 17. As will be seen, the vertical tube is embraced by a bridle which is made of forged steel. The horizontal tube lies between the arms of this bridle and is held in position by a front clamp plate which slides into position behind the lipped ends of the bridle arms. A single screw operated by a tommy bar holds this plate in position and at the same time secures both the horizontal tube and the bridle. A proper seating for the horizontal tube is furnished by a formed distance piece, which is illustrated in Fig. 19, and which slides in behind the tube and hangs on the bridle by means of its upper lugs. Various sections of tubing are connected together by means of square rods fitted inside the tubes. A square section has been chosen for this purpose as it gives a better fit than a round in the unmachined tube. Even if the tube is slightly oval a position can easily be found in which the rod will enter. The vertical members, or standards, of this construction are provided with bases of the type illustrated in Fig. 18. As will be seen the same square section bar is used, secured to a circular base plate.

The illustrations and description will make it clear that the erection of this type of scaffolding can be carried out rapidly, while the details of the joint will show that a stiff construction results. The whole arrangement is very strong. In a successful test carried out by Messrs. John Mowlem & Co. a load of 4 tons 9 cwt. covering an area of 6 ft. by 4 ft. 6 in. was placed centrally on an area 12 ft. by 4 ft. 6 in. which was supported by six tubular standards and had six tubular horizontals. In connection with this steel scaffolding the Tubular Scaffolding Company also supply a patent putlog which does away with the necessity for cutting bricks out of existing works to support the inner ends of the horizontals. This is illustrated in Fig. 20 and it will be seen that it is a type of fletched beam with the underplate projecting at one end. When dealing with existing work it is only necessary to clear a joint and fix the plate with a wooden wedge. With new work the plate is built into a joint and no putlog holes have to be left. The patent putlog is made in lengths of 4 ft. 6 in. and 5 ft. and is, of course, suitable for use with ordinary scaffolding as well as with the firm's tubular construction.

The tubular crane staging which is also manufactured by the Tubular Scaffolding Company, and of which a section is illustrated in Fig. 21, is suitable for building crane towers, gantries, observation towers, &c. Towers are built up of a series of units of the form shown in the figure which are superposed one on another. Each section is secured to the next by eight tie rods. The construction consists of five main tubular members, which at each end fit on to malleable iron sockets. The sockets for the four corner tubes are in each case connected by a tie-rod to the opposite socket on the next level and on the same face of the tower. The arrangement will be understood from Fig. 21, and it will be clear that the sockets are held down on to the rods and that the whole thing is very rigid. The tie rods are hexagonal in order that they may be rotated with a spanner and are screwed right and left handed at the ends. They fit into ball nuts which are provided with spigots which fit into the horizontal holes in the sockets. Cotter pins prevent the ball nuts from coming away from the sockets. The other main members of the tower are a series of square plates with four large circular holes. These fit over the sockets and tie the main vertical members together, preventing deformation or spreading. Four intermediate vertical rods connect the middle points of the edges of these plates. These are secondary members, the chief purpose of which is to add a little extra stiffness to the various platforms which are formed by the plates and to prevent any buckling. The base of the tower, as will be seen, is formed with two plates close together, and may be loaded in the same way as a tower built with spars and lashing.

Access to the top of the tower is obtained through the inside, the circular holes being large enough to admit of a ladder. It is, however, not difficult for a workman to climb up the inside without a ladder, and we understand the maker's workpeople always ascend in this way. Each tower unit is 6 ft. 6 in. high, and they may be built single or in threes or any other way as may be desirable for the work in hand. A single tower carrying any weight at the top will of course normally require guy ropes. As examples of the use of these towers we may quote a recent contract in Leadenhall-street carried out by Messrs. W. H. Lorden and Sons, of Tooting, in which a 3-ton 75 ft. jib crane was carried on a tower 116 ft. high. Another recent case was the erection of the Dover Patrol Memorial in a very exposed position on Dover cliffs, when a 5-ton crane was carried on three of these towers. It will be clear that this construction contains no very small parts, and that it can be rapidly and easily erected, the remarks made earlier in reference to the erection features of the tubular scaffolding applying generally also to the towers.

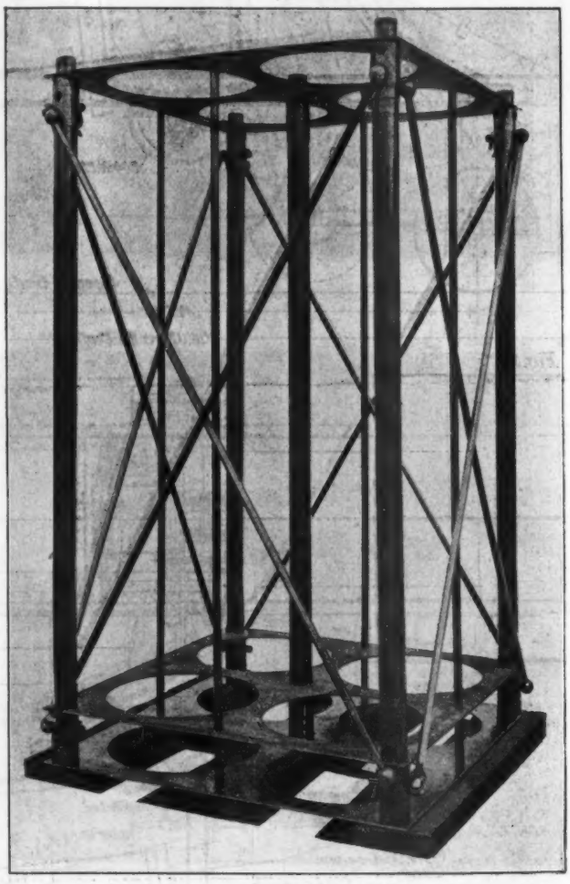


FIG. 21.

Any other plant or machinery which was shown at

the exhibition we are afraid we can on the present occasion give but brief mention to. As it is another example of the substitution of metal for wood, and as it formed a striking feature of the show we may, however, refer to the metal window frame exhibit of Messrs. The Crittall Manufacturing Company, Limited, of Braintree, Essex. The firm showed their various patterns of standard metal windows which are generally well-known and also some very fine examples of bronze windows and doors. Among these latter was one of the entrance doors to the New London County Hall. Metal window frames and bronze doors were also shown by Messrs. Williams and Williams, Limited, of Sardinia House, Kingsway, W.C. 2, and Chester. We believe this firm has been manufacturing steel window frames for some sixty years. Another somewhat allied exhibit was that made by Messrs. G. A. Harvey and Co. (London), Limited, of Woolwich-road, S.E. 7. This included various of Messrs. Harvey's well-known manufactures such as steel shelving and lockers, wall ties, weather vanes, &c. The firm are specialists in all kinds of sheet metal and plate work, and a very attractive feature of their stand was the arrangement of samples of various patterns of ornamental perforated brass sheet.

Before concluding, we must refer to some of the wood-working machinery exhibits of which there was a good display. The machinery shown was naturally in the main of the type likely to appeal to builders and to builders wood-work manufacturers. Thus all, or almost all, exhibitors showed saws and chain-cutter or hollow chisel mortising machines. We may refer for instance to Messrs. J. Sagar and Co., Limited, of Canal Works, Halifax, who in addition to machines of the types we have mentioned showed a general purpose builders tenoning machine, which could also be used for cross-cutting and grooving, and also various planing machines. Messrs. Haighs (Oldham), Limited, of Plane-street, Oldham, showed various saws, mortising machines and planers and also a universal wood-worker which comprised a surface planer, circular saw, mortising, boring and tenoning machine, &c. Messrs. Wadkin and Co., of North Evington, Leicester, had an attractive display with several of their machines in operation, these included their new boring, recessing and stair-stringing machine which was illustrated in our issue for May 20 last year.

A nice display of wood-working machine tools was also made by Messrs. Clark's Machine Tool Company, Limited, of Luton. This included a planing and thicknessing machine, chain and hollow chisel mortisers, &c. The firm also showed a semi-automatic universal grinding and sharpening machine for planing and moulding irons. Mr. A. Cooksley, of 21, 23 and 25, Tabernacle-street, E.C. 2, showed planing and moulding machines of various patterns, while the Dominion Machinery Company, Limited, of Halifax, showed the "Elliot" woodworker which will rip, cross-cut, tenon and cut moulds and trenches. The firm also showed a thicknesser and a chain mortising machine. A very considerable range of tools was shown by the Imperial Wood-Working Machinery Company, of Wylde Green, Birmingham. In addition to machines of many of the types we have already mentioned they showed a pattern maker's lathe, saw benches, grinders, &c. Band saw blades, brazing apparatus for band saws, grinders and similar plant were shown by Messrs. C. D. Monninger, Limited, of 59, Farringdon-road, E.C. 1, while Mr. J. A. Victor, of 77A, Queen Victoria-street, E.C. 4, showed a large number of examples of Danckaet's wood-working machinery.

Induction Motor for United States Super-Dreadnoughts.—At the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company, a number of motors are being built to propel electrically the super-Dreadnoughts included in the naval programme adopted by the Limitation of Armaments Conference. Four motors are required to propel one battleship, one being directly coupled to each of the four shafts. Each motor is rated at 16,500 h.p. at 227 r.p.m. The motors are designed for the most economical operation at two speeds of the ship—full speed of 23 knots and cruising speed of 15 knots. This result is obtained by the use of two entirely separate stator and rotor windings in the motor. At the full speed, one set of windings is used and, at the cruising speed, the other set is operative.

INDUSTRIAL NOTES.

We deal in a separate article in the present issue with the crisis in the engineering and shipbuilding industries.

Mr. C. T. Cramp, secretary of the National Union of Railwaymen, recently approached the Associated Society of Locomotive Engineers and Firemen, with a view to the fusion of the society with the National Union of Railwaymen. Mr. J. Bromley, secretary of the society, stated that the latter "had no intention of departing from a policy which had served so well the interests of the locomotive men, to the mutual advantage of themselves and other grades in the railway service." Mr. Bromley added that when the same earnestness is manifested by the National Union of Railwaymen for co-operation or federation with the society as exists for fusion, the executive committee of the society will be pleased to extend the hand of fellowship with the object of safeguarding the interests of all concerned. The society was still prepared to consider a scheme of federation which provided for separate and distinct autonomy for each organisation.

It is announced that the following agreement has been arrived at between the employers in the vehicle building industry and the Union of Vehicle Builders, the Society of Wheelwrights and Smiths, and the Woodcutting Machinists:—

Skilled men in grade 1 towns to suffer a reduction of 3d. per hour in two instalments, the first of 1½d. on May 1, and the second on September 1.

Workers in grade 2 towns to receive 1d. below the minimum for grade 1 towns, and workers in grade 3 towns to be similarly reduced.

The 47-hour week to continue unless extended in the engineering trade.

Overtime to be paid at special rates.

Payment by results may be introduced by agreement.

The men's leaders state that the agreement is the best among those recently negotiated by other trade organisations. It is to remain in force until March 1, 1923.

The committee formed of representatives of employers and labour appointed in September last to inquire into the working and effects of the Trade Boards Acts, under the chairmanship of Lord Cave, has made its report to the Labour Minister. The report says that whilst the effect of the Trade Board system on trade and industry has occasionally been stated in terms of exaggeration, there is substance in the allegation that the operations of some of the Boards have contributed to the volume of trade depression and unemployment. Unfortunately for the system, many of the increases in wages settled by the Boards came into operation at a moment when trade was failing, and in some instances the additional burden so imposed on traders made it difficult for those traders to adjust themselves to the altered conditions. An increase in cost of production can, within certain limits, be passed on to the consumer, but in time a point is reached where the consumer ceases to buy, then follow decline of trade, the closing of workshops, short time and the discharge of workers. This result is more quickly reached where the trade is subject to foreign competition. On the other hand, the system has had beneficial effects, for, speaking generally, Trade Boards have succeeded in abolishing the grosser forms of under-payment and in regularising wage conditions in trades brought under the Acts. It has also contributed, on the whole, to the improvement of industrial relations, having brought the two sides together round a table and so enabled each side to understand something of the other's point of view. The committee then make a number of recommendations and amendments, the last recommendation being to the effect that the Trade Board Acts be repealed and a Consolidating Act passed containing the necessary amendments. The report is in the form of a white paper, Cmd. 1645.

The Ministry of Labour state that employment during March, though still bad generally, showed a further slight improvement on the whole, notwithstanding the adverse effect of the engineering dispute on employment in that industry and in the iron and steel trades. Among industries showing an improvement were iron mining, pig-iron manufacture, the building trades, the cotton and wool textile industries, and the clothing trades. The percentage unemployed among members of trade unions from which returns are received was 16·3 at the end of March, the same as at the end of February. The percentage unemployed among the 12,000,000 workpeople insured under the Unemployment Insurance Act was 14·6 on March 27, as compared with 15·2 on February 28. The percentages for males and females at March 27 were 16·7 and 9·3 respectively. The total number of workpeople registered at the Employment Exchanges as unemployed on March 27 was approximately 1,740,000, of whom 1,359,000 were men and 285,000 were women, the remainder being boys and girls. On February 28 the number on the live register was 1,837,000, of whom 1,411,000 were men and 318,000 were women. In addition to those unemployed, 132,000 males and 91,000 females were registered on March 27 as working systematic short time in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On February 28 the corresponding figures were 155,000 males and 105,000 females. The number of vacancies notified by employers to Exchanges and unfilled on March 27 was 17,600, of which 4,200 were for men and 11,200 for women, compared with 18,000 on February 28.

The changes in rates of wages reported as having taken effect in March, in the industries covered by the statistics, resulted in a reduction of over 223,000*l.* in the weekly full-time wages of about 1,350,000 workpeople and in an increase of 800*l.* a week in the wages of about 10,000 workpeople. Coal miners in Northumberland, Yorkshire, the East Midlands, Lancashire, Cheshire, North Staffordshire, North Wales and Scotland sustained reductions varying in amount from under 2 per cent. to over 8 per cent. on current rates of wages; in the Forest of Dean and the Radstock District, on the other hand, there were increases equivalent, respectively, to nearly 1 per cent. and over 8 per cent. on current rates. In the merchant shipping service the rates of pay of ordinary seamen were reduced by 25*s.* a month, and those of other men by 30*s.* a month; for men on weekly rates the reductions ranged from 8*s.* to 10*s.* 6*d.* per week. There was a general reduction of 1*s.* per day, or 6*d.* per half-day, in the time rates of wages of dock labourers, with corresponding reductions in piece rates. Men in the heavy chemical trade sustained a reduction of 1*d.* per hour, and those in flour mills a reduction of 1*s.* 6*d.* per week. Among other large groups of workpeople whose wages were reduced were iron puddlers and millmen in the North of England and the West of Scotland; ship repairers in South Wales; electrical cable makers; wire drawers; lead smelters; textile warehousemen in London; and rubber workers in Lancashire. Minimum rates of wages fixed under the Trade Boards Acts were reduced during the month in a number of trades. Since the beginning of 1922 changes in rates of wages reported to the Department have resulted in a net reduction of 1,210,000*l.* in the weekly rates of wages of nearly 5,900,000 workpeople and a net increase of about 3,400*l.* in the wages of 20,000 workpeople.

The number of trade disputes involving stoppages of work, reported as beginning in March, was 48. In addition, 53 disputes, which began before March, were still in progress at the beginning of the month. The total number of workpeople involved in all these disputes (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 280,000, as compared with 33,000 in the previous month and 45,000 in March, 1921. The estimated aggregate duration of all disputes during March was about 3,500,000 working days, as compared with 316,000 days in February, 1922, and 839,000 days in March, 1921. The principal disputes were those in the engineering and shipbuilding industries, which are estimated to have involved about 240,000 workpeople.

On April 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 82 per cent. above that of July, 1914. The corresponding figure for March 1 was 86 per cent., and that for April 1, 1921, was 133 per cent. The highest point reached by the figure was 176 per cent. above the pre-war level—in November, 1920. Apart from a slight interruption in the summer of 1921, there has been a continuous decline since that date, and the figure now recorded is lower than that for any date since October, 1917.

Wood Splinters and Fibres.—It is a common impression among wood-workers that wood which in breaking shows long splinters has therefore longer fibres than material which breaks off short, but this is not necessarily the case. A sample of timber recently submitted for examination to the Forest Products Laboratories of Canada, Montreal, was described by the sender as weak, brashy and with short fibres. On examination with the microscope, however, the fibres were found to be unusually long for that particular kind of wood. It is stated by the laboratories that there is, in fact, no known relationship between the length of splinters and the length of the fibres or cells of which wood is composed. Further, it is stated that no apparent relationship exists between the length of the fibres and the strength of any piece or kind of wood.

SPECIAL SERVICE VESSEL "SIR FREDERICK DUMAYNE" FOR CALCUTTA.

CONSTRUCTED BY MESSRS. BOW, McLACHLAN AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, PAISLEY.

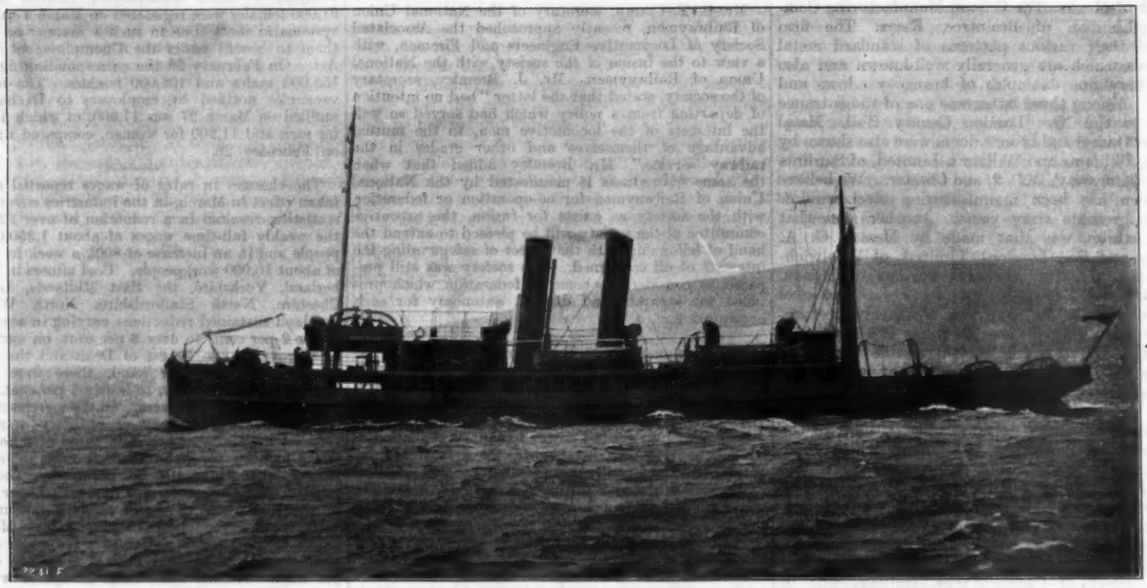


FIG. 9. VIEW OF VESSEL ON TRIALS.

THE "Sir Frederick Dumayne," which we illustrate above, and on Plate XXII, published with this issue, has been built by Messrs. Bow, McLachlan and Co., Limited, Thistle Works, Paisley, for the Calcutta Port Commissioners in order to replace a smaller and less powerful vessel of the same class, named Retriever, lost in 1919. The duties of the new vessel include the towing of ships against the swift currents of the Hoogly River, and for this work she has been fitted with particularly powerful propelling machinery; she is, in fact, probably the most powerful ship of her type in existence. Other duties are the lifting of the buoys which mark the navigable channel and the carriage of fresh water to the lightships at the Sandheads.

The principal dimensions of the ship are: Length between perpendiculars, 212 ft.; breadth, 32 ft., and moulded depth, 15 ft. 3 in. Her appearance is well shown in Fig. 9 and also by the rigging plan, Fig. 1, on Plate XXII. In addition to the raking foremast, it will be noted that a vertical Samson post is fitted aft, and this is provided with a 12-ton derrick. The vertical post, it must be admitted, gives the vessel a rather peculiar appearance, but the advantages of the arrangement in connection with the working of the derrick were rightly regarded as of greater importance than purely aesthetic considerations.

The general arrangement of the vessel can be followed by an inspection of the profile, Fig. 2, and the deck plans, Figs. 3 to 6. From these it will be seen that accommodation for the officers is provided in deck-houses on the upper deck and shade deck. The rooms are particularly large and airy, and each is provided with an electric fan, 3 ft. in diameter. The bath, lavatory and other sanitary arrangements are also ample. The propelling machinery, which was supplied by the builders, comprises two sets of triple-expansion, surface-condensing engines having cylinders 18½ in., 30 in. and 50 in. in diameter, with a piston stroke of 36 in., and driving twin screws. Steam is supplied by two double-ended marine boilers, 12 ft. 6 in. in diameter by 18 ft. long, working at a pressure of 180 lb. per square inch. The boilers are coal fired and Howden's system of forced draught is fitted, the fan being mounted on the upper deck between the uptakes, as shown in Fig. 2. Coal is carried in two cross-bunkers, one situated between the boiler-room and the engine room and the other forward of the boiler room. A Cochran vertical donkey boiler is fitted in a recess in the forward cross-bunker, as shown in the plan of the lower deck, Fig. 6. Cargo is carried in a hold forward and also in a space aft of the engine-room. In the double-bottom tanks, which extend right fore and aft, 50 tons of reserve feed water can be carried as well as 20,000 gallons of fresh water for supplying lightships.

The auxiliaries constructed by the builders include a steam steering engine situated on the upper deck aft of the engine casing, screw steering gear fitted on the rudder stock, centrifugal circulating pumps, and a steam-driven centrifugal salvage pump. The latter, which is of the 9-in. size, is mounted on the upper deck near the steering engine, as shown in Fig. 5. A steam exhauster is fitted on the impeller casing to enable the pump to draw from the sea, or from the hold of another vessel, without priming. During the sea trials, which are referred to below, the satisfactory working of the pump was amply demonstrated. Other auxiliaries fitted include condensing plant having air and circulating pumps by Messrs. Dawson and Downie; main and auxiliary feed pumps, feed-water heater, two general service pumps and a fresh-water pump, by Messrs. G. and J. Weir, Limited; a 20-ton evaporating and distilling plant, by Messrs. Caird and Rayner; and two 20-kw. electric generators driven by Bellis and Morcom engines. These generators supply current for the searchlight and the wireless installation, as well as for the ship's lighting, fans, &c.

Special gear is fitted to deal with the heavy and sudden loads to which the fittings are subjected when towing. Controlled from the aft end of the shade deck are two large steam capstans, constructed by the shipbuilders, the engines being situated on the lower deck and the capstan heads on the upper deck, as shown in Figs. 5 and 6. The capstan heads carry a bridle, to which the towing hawser is attached, and the heads, together with the Risk's patent guide rollers leading to them, are of a size suitable for the 22-in. circumference coir hawser used in the vessels' ordinary towing work. The towing arrangements are shown in Fig. 5, and a view of that part of the upper deck on which the gear is situated is reproduced in Fig. 7. In Fig. 8 the steam winch and windlass fitted on the shade deck forward are shown. The windlass, which was constructed by Messrs. Clarke, Chapman and Co., Limited, is fitted with four cable holders, and, in accordance with the requirements of the Calcutta Port Commissioners, has been made of three times the usual strength. For the work of lifting buoys, above referred to, substantial gear is provided, including two davits 10¾ in. in diameter on both the port and starboard sides. The davits, which are situated near the foremast and can be seen in Fig. 9 above, are most clearly shown in the plan of the shade deck, Fig. 4, on Plate XXII; each is designed for a lift of 5 tons. Three lifeboats and a gig, each measuring 25 ft. by 7 ft. 9 in. by 3 ft. 2 in., are carried on the shade deck.

The vessel was built under the supervision of Lloyd's surveyors and of Mr. J. Angus, the consulting engineer and agent to the Calcutta Port Commissioners. The sea trials were carried out at Skelmorlie, on January 11 and 12 of this year, the highest speed attained being 14¼ knots. At this speed the engines ran at 114 r.p.m., and the total indicated horse-power was 2,800. The trials were satisfactory in all respects and on their completion the vessel left for India.

VERTICAL GRINDER WITH 6-FT. ROTARY TABLE.

AT the time of the Machine Tool Exhibition at Olympia in 1920 we illustrated two new models of large grinding machines by the Lumsden Machine Company, Limited, of Gateshead, for whom Messrs. Alfred Herbert, Limited, of Coventry, act as agents. One of these was a vertical spindle machine using segmental wheels, the table being of the planer type. The other was a horizontal spindle type using a 30-in. segmental wheel. Developed from this latter machine the firm have since produced a horizontal spindle machine having a 15-ft. table, while from the former has been developed an interesting design of which we are now able to give illustrations and a few details.

The No. 94 type machine to which we now refer is illustrated in Figs. 1 to 5 opposite, and on page 524 From these it will be seen that it is furnished with a large rotating worktable, the diameter of which is 72 in., while mounted on the table is a magnetic chuck, 63 in. in diameter.

A reference to our former description and illustrations (page 304, vol. cx of ENGINEERING) will reveal points of resemblance between the two machines in the cross-rail and housings. The tables are, of course, quite unlike. In the new machine now illustrated the table is mounted on circular ways, and has a large central stem which revolves in vertical bearings in the bed. The two housings are dissimilar, as in the earlier machine, one being a large cylindrical pillar, while the other is of the planer type. The cross-rail is formed at one end with a large sleeve which fits the column and is carried by it much in the manner of the arm of radial drill. At the other end the cross-rail is fitted with a slide which works on vertical ways on the planer type housing. The two housings are connected at the top by a heavy cross-rail and the whole forms a very robust design, the long sleeve giving excellent support to the wheel cross-rail. This cross-rail is locked in position when grinding. The maximum height from table to wheel face is 19½ in. The rail is elevated by power by belt drive from the main motor.

The latter is of 40 h.p., arranged in the top rail with vertical spindle. The elevating drive is from this motor by means of open and crossed belts at the back of the housings and the small belt on the overhung pulley at the back end of the jockey pulley spindle, down to a worm drive at the back of the bed. This drive is fitted with heavy ball thrust washers. The elevating nut in the cross-rail is fitted with pivotal bearings. The elevating movement is thrown in or

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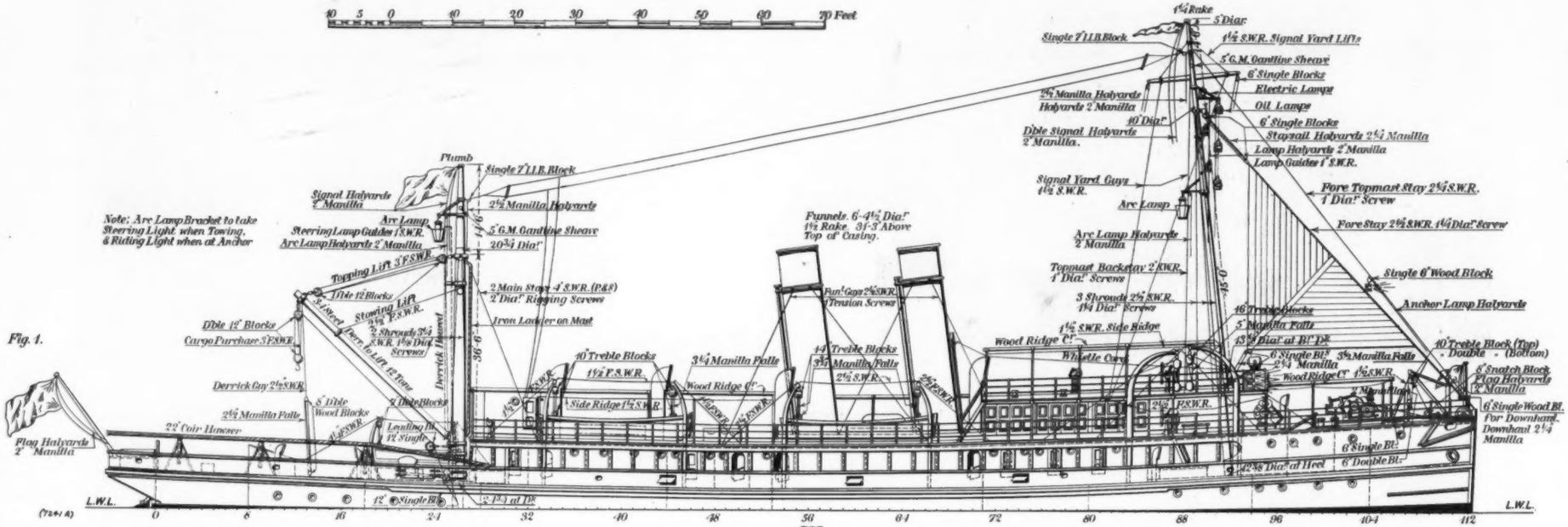
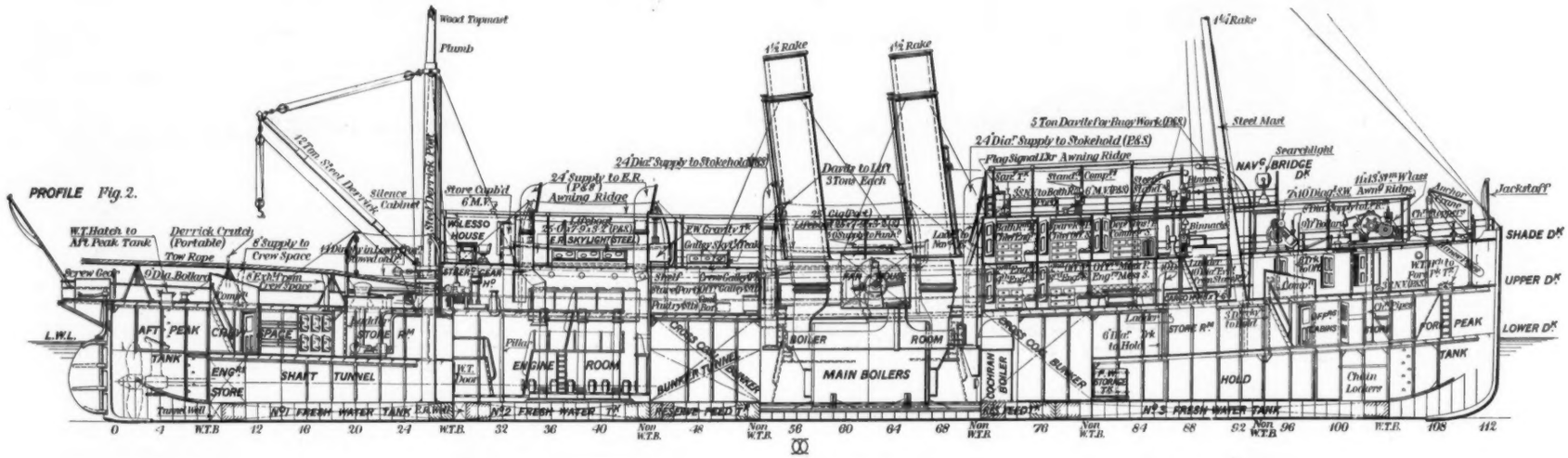
(*For Description, see Page 520.*)

Fig. 1.

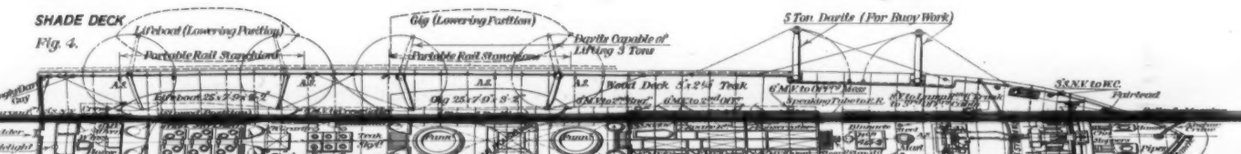

40 5 0 40 20 30 40 50 60 70 Feet
Plumb
Single 7" I.L.B. Block
Signal Halyards 2" Manilla
2½ Manilla Halyards
Arc Lamp
Steering Lamp Guides 1" S.W.R.
Arc Lamp Halyards 2" Manilla
5' G.M. Gantline Sheave
20¾ Dia.
Note: Arc Lamp Bracket to take Steering Light when Towing, & Riding Light when at Anchor
Topping Lift 3" F.S.W.R.
Tble 12" Blocks
Storing Lift 2½ F.S.W.R.
2 Shrouds 3¼ S.W.R. 1⅛ Dia. Screws
Dble 12" Blocks
Cargo Purchase 3" F.S.W.R.
Derrick Gay 2½ S.W.R.
5" Dble Wood Blocks
2½ Manilla Falls
2 Dble Blocks
22" Coir Hawser
Leading Bl. 12" Single
Flag Halyards 2" Manilla
Derrick Thwart
36'-6"
2 Main Stays 4" S.W.R. (P&S) 2 Dia." Rigging Screws
Iron Ladder on Mast
10" Treble Blocks
1½ F.S.W.R.
3¼ Manilla Falls
Wood Ridge Cr
Side Ridge 1½ S.W.R.
Funnels. 6-4½ Dia." 1½ Rake. 3'-3" Above Top of Casing.
Fun.l Guy 2½ S.W.R. Tension Screw
14" Treble Blocks
3½ Manilla Falls
2½ S.W.R.
Wood Ridge Cr
1½ S.W.R. Side Ridge
Whistle Cord
1¼ Rake
5" Dia.
Single 7" I.L.B. Block
1½ S.W.R. Signal Yard Lifts
5' G.M. Gantline Sheave
6" Single Blocks
Electric Lamps
Oil Lamps
6" Single Blocks
Stayrail Halyards 2½ Manilla
Lamp Halyards 2" Manilla
Lamp Guides 1" S.W.R.
2½ Manilla Halyards
Halyards 2" Manilla
40' Dia."
Dble Signal Halyards 2" Manilla.
Signal Yard Guys 1¼ S.W.R.
Arc Lamp
Arc Lamp Halyards 2" Manilla
Fore Topmast Stay 2½ S.W.R. 1" Dia." Screw
Fore Stay 2½ S.W.R. 1¼ Dia." Screw
Topmast Backstay 2" S.W.R. 1" Dia." Screws
3 Shrouds 2½ S.W.R. 1¼ Dia." Screws
Single 6" Wood Block
Anchor Lamp Halyards
16" Treble Blocks
5" Manilla Falls
13¾ Dia." at Bl." D.K
6" Single Bl." 3¾ Manilla Falls
2¼ Manilla
Wood Ridge Cr
1½ S.W.R.
2" Manilla
10" Treble Block (Top) " Double " (Bottom)
8" Snatch Block Tag Halyards 2" Manilla
6" Single Wood Bl. for Downhaul. Downhaul 2¼ Manilla
2½ F.S.W.R.
6" Single Bl.
6" Double Bl.
22½ Dia." at Heel
L.W.L.
0 8 16 24 32 40 48 56 64 72 80 88 96 104 112

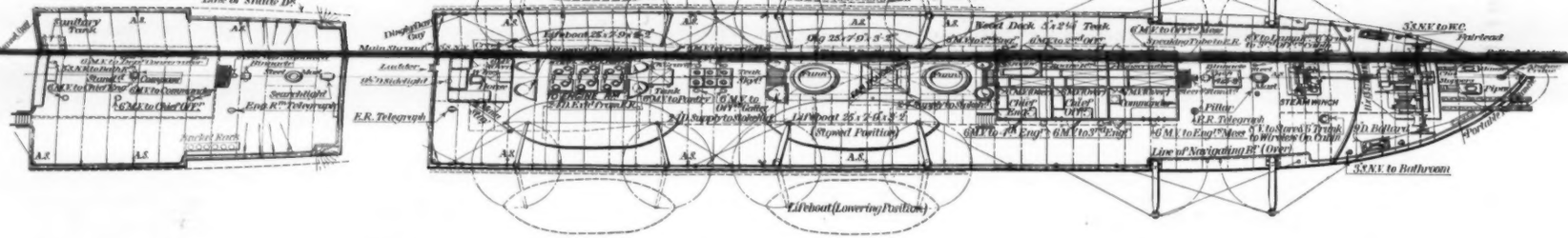
PROFILE Fig. 2.

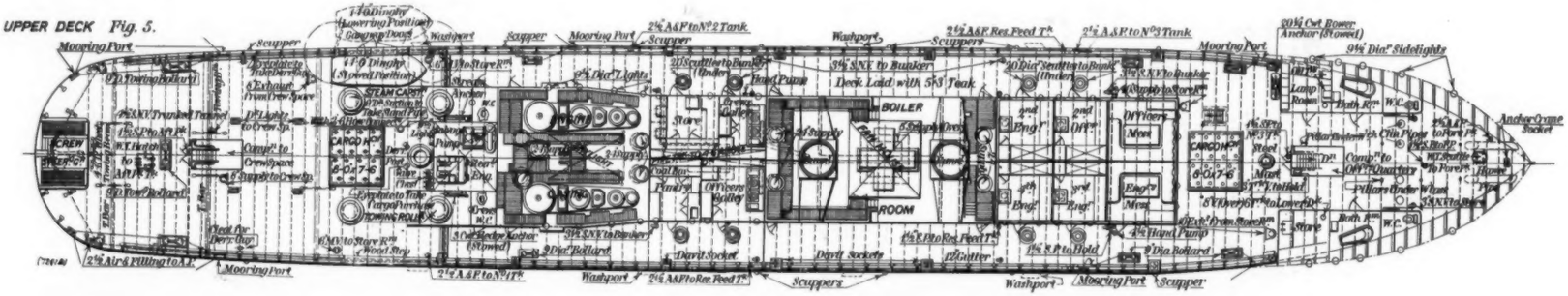


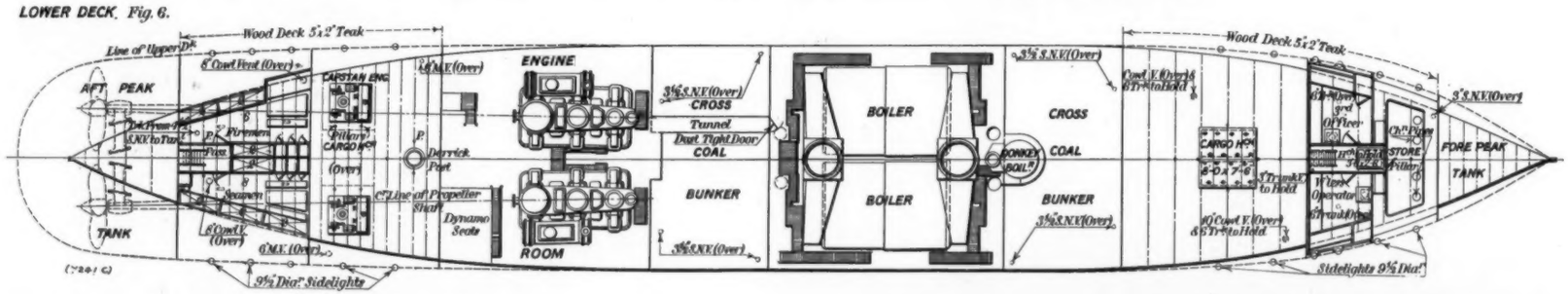
NAVIGATING BR. DECK Fig. 3.

SHADE DECK Fig. 4.









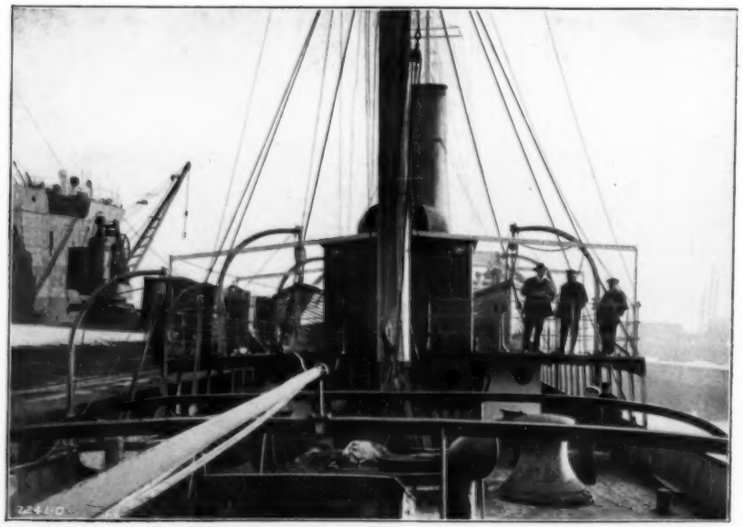


FIG. 7. AFTER PART OF UPPER DECK SHOWING TOWING GEAR.

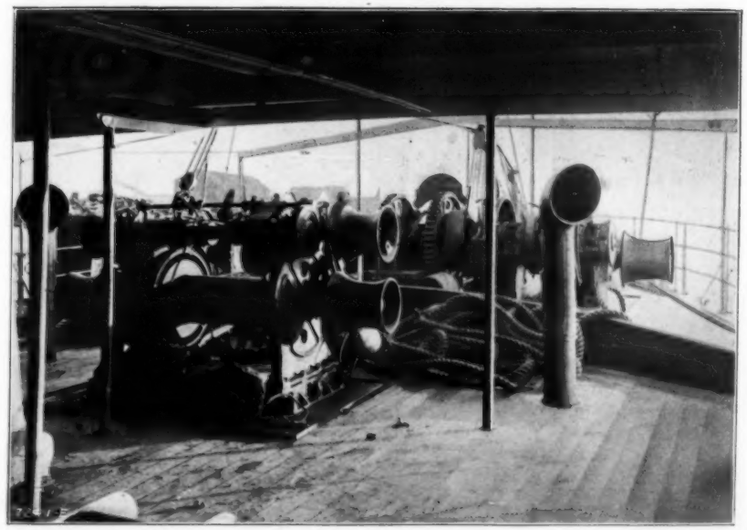


FIG. 8. STEAM WINCH AND WINDLASS ON SHADE DECK FORWARD.

out by means of the handle on the vertical spindle on the cross-rail toward the left or sleeve end.

The table drive is from the main motor in the top rail over the two jockey pulleys at the top of the left-hand column, and down to a pulley on a change-speed box fitted with positive and friction clutches, and giving two speeds of 4 r.p.m. and 6½ r.p.m. The speed-change mechanism is arranged so that the friction clutches come into operation before the positive clutches engage, thus avoiding shock. The change-speed box is controlled by the horizontal handle, and connected with the diagonal spindle seen on the right-hand side of the bed in Fig. 5. This connects through to the box on the other side of the machine. The table can be stopped and inched for setting work, quite easily.

The grinding wheel is of the segmental type, and 37 in. in diameter. It overlaps the centre and periphery of the table each by ½ in. The wheel is made up of 18 segments held in a chuck by adjustable and floating wedges. It is possible when grinding large surfaces in order to promote rapid cooling and freer cutting to withdraw half the segments out of action. This has a very marked effect in improving output. The grinding wheel spindle is carried in a large cylindrical ram housed in the cross-rail. The spindle runs on ball and roller bearings and is provided with a special design of double ball thrust bearing. The spindle is driven direct by the vertical motor overhead by means of a telescopic connection. The speed of the wheel is 520 r.p.m. The wheel, spindle and ram are all counterbalanced inside the cross-rail, so that there is no tendency for the wheel to fall during cutting. The feed of the wheel is obtained by the vertical movement of the ram in the cross-rail. This movement is restricted to 1¼ in. A pointer attached to the balancing lever indicates the amount of any adjustment. This pointer will be noticed in Fig. 4.

The wheel feed when operated by hand is obtained with the large hand wheel at the right-hand end of the cross-rail. Automatic feed is derived from the vertical spindle seen reaching up to this wheel from the ratchet gear below. The drive of this gear is from the main gear box on the other side of the machine, through a friction device, and the mechanism embodies a quadrant and pawl and ratchet for obtaining variations of feed from between 0·005 in. to 0·0005 in. per revolution of the table.

The work and wheel are kept liberally supplied with water from a large tank at the back of the machine, delivered by two wide nozzles, one on each side of the wheel. The table has a trough cast all round it, discharging at the back into the tank. Splash guards hinged on pillars, and easily removable, surround the work.

In Figs. 6 to 11, page 524, we illustrate typical examples of work on which this machine can be effectively employed. Fig. 6 shows the facing of small cast-iron gears, 6 in. over the teeth, and finished to 1 7/16 in. width. Fifty-six of these wheels can be placed on the magnetic chuck at a time and finished on both sides, taking off a total of 1/16 in. in 8 minutes, or less than 9 seconds each. Another typical instance is of cast-iron brackets 16½ in. long, 3½ in. deep and 1 5/16 in. thick finished. Taking 1/16 in. metal off these, they were finished in lots of 24, on both sides, in 28 minutes, or a little more than 1 minute each. Cast-iron radial bars of two patterns were grouped together on the chuck, to the number of 27 pieces, and ground on each side to finished size in 30 minutes; taking off the two sides together a total of 1/16 in. metal. One of these radial bars is shown in Fig. 11. The other was somewhat smaller and differed in shape.

One of the most interesting uses to which this machine may be put is the grinding of large flat surfaces of thin material. Fig. 9 shows four cast-iron shrouding pieces ½ in. thick, held on the large chuck and finished in 15 minutes, on one side, the metal removed amounting to 0·03 in. and 0·04 in. This gives less than 4 minutes per piece, the overall dimensions of the large sheets being 2 ft. 6½ in. by 3 ft. 0½ in. The plain segmental pieces have an overall length of 3 ft. 10½ in. In other instances were pieces of segmental shrouding so long that only two could be got on the machine; they were finished at the rate of two in 8 minutes on one side. A particularly good example of work is shown in Figs. 7 and 8, illustrating the grinding of cast-iron gear covers. These are very thin castings with flanges only ½ in. thick. The magnetic chuck is of course excellent for such work, which would easily strain if held down by the ordinary methods. These covers can be faced all round the edges at the rate of three in 3 minutes. Our last illustration, Fig. 10, shows thin steel plates of ½ in. to 1/16 in. thickness being ground on one side. As typical of this class of work we may say that two 33½-in. by 21-in. plates can be ground all over on one side in 30 minutes. Four plates, 30 in. by 8 in., are disposed of in 20 minutes, or three 34-in. by 14½-in. plates in 20 minutes. If, as in the latter instances, the plates can be spread round the circumference of the chuck, the higher table speed can be used and the time reduced to from 15 minutes to 20 minutes. In these cases of plate grinding, as already stated the segments in the grinding wheel are reduced in number from the normal 18, to 8.

FIG. 1.

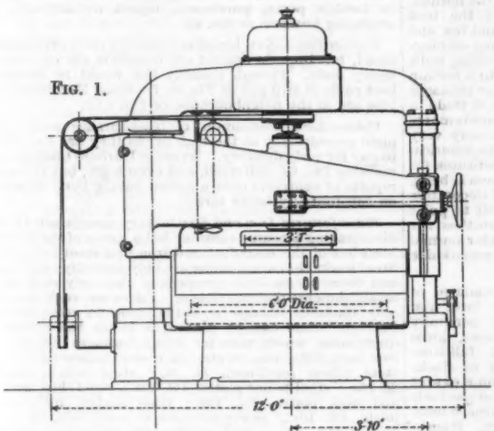


FIG. 2.

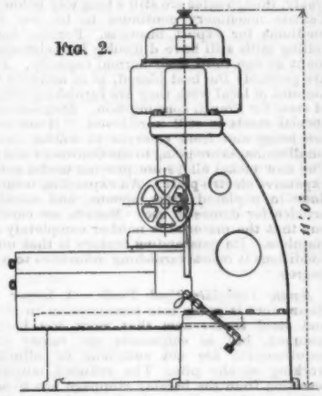
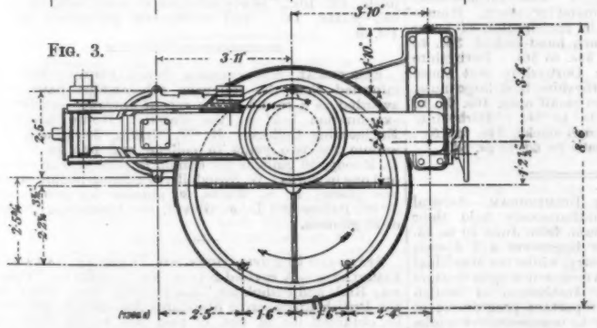


FIG. 3.



INSTITUTION OF NAVAL ARCHITECTS: ERRATUM.—In the report, in our issue of April 14, of Mr. R. J. Walker's contribution to the discussion on double-reduction gearing, page 446, first column, the factor of safety given as 4 to 1 in line 5 from top should be 40 to 1, and in the following line the factor of safety 10 to 1 should read 100 to 1.

TRIALS OF THE MOTOR SHIP "SEGOVIA."

THE great amount of interest being shown at the present time in motor ships and in marine Diesel engines, gives evidence that, when conditions again permit of the normal amount of ship construction, the motor ship will, in all probability, be in a favoured position. In keeping with the broad and generous policy now being generally pursued, the North Eastern Marine Engineering Company of Wallsend-on-Tyne recently extended invitations to a large number of people influential in shipping and marine engineering circles, to witness trials of their Werkspoor Diesel engines fitted on board the motor ship Segovia, built by Messrs. Wood, Skinner and Co., of Newcastle, for Christiania owners. This ship is a sister to the Sevilla,* which has now been in successful service since her completion. It is unnecessary here again to enter into the details of the installation, but it may be of interest to give some further impressions gained from a closer inspection of the engines in operation, and of the equipment.

In this ship no boiler is fitted, thus making for the maximum economy of operation—a system which is gaining ground. The main engines were run at various speeds and revolutions, and were frequently manœuvred. The system of reversing, by means of which the valve levers are mounted on eccentrics keyed at an angle askew to their fulcrum shaft, worked in an entirely satisfactory manner. With the large cam rollers adopted, the fact that the roller only has a very short line of contact during the relatively short period when the engine is going astern, causes no inconvenience. The various shafts at the top of the engine at the back, are the camshaft, the fulcrum shaft already mentioned, and a further fore and aft shaft carrying cams which, through a system of bell-crank levers, serves by rotation and the action of further secondary cams to throw the air and fuel valve in and out of action, thus permitting starting up in the normal manner—(1) six cylinders on air; (2) three cylinders on air and three cylinders on fuel; and (3) six cylinders on fuel. These shafts are so spaced as to permit of ready access for examination or overhaul. The camshaft is driven from the crankshaft by spur gearing at the bottom, and four long connecting rods.

The rotation of the camshaft.—The raising of the valve levers from off one set of cams, say, for ahead, and lowering again on to the astern cams (it may be mentioned that this applies to the inlet, exhaust and starting air, but not to the fuel valve levers) is carried out by a piston operated by compressed air through the medium of a rack and pinion. Alternatively hand gear is provided against the remote contingency of the servo-motor being out of action. Rotation of the secondary shaft carrying the cams controlling the starting operations is carried out by hand. The six cylinders are fitted with relief valves which, when operated by compressed air on stopping the engine, relieve the compression in the cylinders, and so facilitate restarting.

The engine control is also interesting, in that the lever controlling the servo-motor, for the rotation of the fulcrum shaft for reversing the valve gear, is so interlocked with the engine room telegraph that, on an "astern" order being given, it is impossible to put the engine "ahead," and, similarly *vice versa*. The very small amount of power required to effect the rotation of the secondary shaft controlling starting permits this to be done by hand, and the various movements from six on air to three on air and three on fuel, and thence to six on fuel, are carried out without any intermediate pause; this is a point of considerable advantage. As soon as the engine has picked up on fuel on three cylinders it is immediately put to the six on fuel position.

The main features of the Werkspoor design are so well known that detailed description is scarcely necessary. The system of fuel injection is of the standard Werkspoor design, and one pump only is in action normally, delivering fuel to a balanced reservoir above the cylinder heads, which reservoir is under the injection air pressure. From this reservoir the fuel is distributed to the six cylinders. Control of the pump is automatic from the reservoir. There are two such pumps on the engine, one working and one spare. In addition for priming through the system or as an additional stand-by, there is a similar independent high-pressure fuel pump, driven by the electric motor, the main purpose of which is to operate the main engine turning gear.

The balance of power amongst the six working cylinders can be checked by taking indicator cards. The indicator gear consists of cams on the camshaft operating levers. Thermometers are fitted in all the exhaust outlets and serve as a good guide to the power developed in the various cylinders. Furthermore the Hawkes-Hunter indicator has been installed; this, by means of a number of cocks and

* See ENGINEERING, page 12, *ante*.

a rotating member, puts a pressure gauge into communication with each cylinder in turn, at the same point in the combustion cycle. The readings on the pressure gauge are no index of the total power developed, but are merely comparative as showing the distribution of the power amongst the six cylinders. Throughout the trial the engine started and reversed with ease, running quietly and smoothly with a clear exhaust from 30 r.p.m. to 80 r.p.m. Air for starting is stored in large boiler construction reservoirs, two on each side of the engine room. The normal pressure is 250 lbs. to 300 lbs. per square inch. The injection air compressor is driven by levers from the crosshead of one of the main lines, and is of the Werkspoor three-stage type, delivering to two large blast air bottles at the front of the engine. The engine is complete with all pumps, also driven from the same levers.

The oiltight splash doors are well arranged, and completely prevented leakage. As a matter of interest one of these doors was of glass with an internal rubber wiper worked by an external handle for clearing the oil from the inside of the glass. Through this door the operation of the engine could readily be observed. This fitting must be a great comfort to those marine engineers who do not feel at ease unless they can see the cranks turning and observe the condition of the lubrication arrangements.

For generating electric power there are two three-cylinder Diesel generators of the same type as the main engines, each of 150 h.p., and to one is coupled as well as its 100 kw. generator, a quadruplex Reavell compressor for charging bottles and making up starting air. In addition, for port use there are two 12 h.p. Kromhout semi-Diesel engines driving generators, and it was noticeable during these trials, when one of these small oil engines was running, that more noise was produced than by larger units in the engine room.

The whole installation has been carried out thoroughly, and as of interest it should be stated that, with such a complete plant, utilising the latest types and designs for the various units, the total fuel consumption for all purposes at sea is 3¼ tons per day.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 19th inst., at 49, Cromwell-road, South Kensington, Dr. C. Chree, F.R.S., president, in the chair. The following papers were read:—

(1) "*The Relationship between Rainfall and Temperature as shown by the Correlation Coefficient*," by W. T. Russell. As a preliminary to an investigation into the relative influence of weather factors in the causation of disease it seemed necessary to determine the relationship between the meteorological phenomena themselves. For this purpose two of the factors—rainfall and temperature, were analysed by the method of the correlation coefficient. The principal points revealed by the analysis are (*a*) that the temperature of any two successive months over a series of years is correlated to the extent of approximately +0·3. As the mean monthly temperatures for the twelve calendar months follow very closely a sine curve the coefficient of correlation should be unity. (*b*) There is no definite relationship between rainfall in successive months, but rainfall in alternate months shows some fairly high correlation coefficiencies. For example, the coefficient found between the rainfall of June and that of August in London is as high as +0·55. (*c*) There is a well-marked negative correlation, which is as high as 0·5, between rainfall and temperature in the same month in summer—evidence of the effect of solar radiation. On the other hand, positive coefficients are found for the winter months. The change must be attributed to the beneficial influence of the ocean in maintaining a temperature greatly in excess of what is due to mere latitude and season.

(2) "*The Correlation of Weekly Rainfall*," by R. A. Fisher, M.A., and Winifred A. Mackenzie, B.Sc. Forty years' rainfall data divided into weekly periods, supply about 2,000 values; this quantity is sufficient, with proper treatment, to yield information of some accuracy in respect of rainfall correlation. The existing data for York, Aberdeen and Rothamsted have been examined with a view to establishing adequate methods and exploring the main features of weather localisation. The mean correlations, measured on the ζ-scale, fall off with increasing distance in a regular manner. It is not improbable that simple laws may connect these quantities over considerable areas, which will afford sufficiently exact knowledge of the accuracy of meteorological estimates, based on a limited number of stations. A well-marked annual periodicity in the rainfall correlations rises relatively slowly in the autumn, and for our longest distance (375 miles) the autumn values remain for about three months close to the mean value for the year.

(3) "*The Lunar Atmospheric Tide at Aberdeen*, 1869–1919," by Professor S. Chapman, F.R.S., and Miss E. Falshaw, M.Sc. The lunar atmospheric tide at a second British station, Aberdeen, has been determined by similar methods to those formerly employed for the Greenwich records. The series of observations available was somewhat shorter than that for Greenwich—fifty-four years as against sixty-four years—and as Aberdeen is more disturbed the probable error of the result is rather greater for Aberdeen. The phases of the tide at the two stations agree as well as can be expected, while the Aberdeen amplitude appears to be slightly greater than the Greenwich amplitude. The actual figures for the two stations are in mb. of mercury, Aberdeen $0{\cdot}0188 \sin(2t + 104°)$; Greenwich $0{\cdot}0121 \sin(2t + 114°)$.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While it is easily possible to overestimate the extent of the reported revival, there is unquestionably an abundance of overseas inquiries for steel, machinery and tools, and a marked diminution in Continental competition. After a long spell of depression, signs of activity are beginning to appear in agricultural machinery and automobile parts and fittings. In neither case has local production been affected, as makers have on hand heavy stocks which cannot be liquidated for several months. Substantial business in machinery and steel products is in negotiation with South Africa, Australia and New Zealand. A certain amount of trade is to be done with Latin-American Republics, though this is chiefly in lower grade products, and only where extended credits can be allowed. Export business in mining steel and machinery is restricted owing to foreign labour troubles. Tool-makers are rather better placed than a month ago. Increased tonnage of files, saws, pincers, and edge tools is going to the Colonies. The home agricultural industry is buying rather more freely, though sales are still a long way below the normal. Textile machinery continues to be one of the best mediums for export business. Forges, foundries and rolling mills still have difficulty in maintaining employment at one-third their normal capacity. Rolling mills are probably the best placed, as in addition to a certain amount of local work they are furnishing minor tonnages of steel for French consumption. Stagnation in trade in special steels is still unrelieved. Home requirements are being met from reserves at works, and only very small tonnages are going to the Continent and to America. The new nickel alloys are proving useful substitutes for expensive electro-plate. An expanding business is being done in unplated forks, spoons, and small decorative articles for domestic use. Makers are careful to point out that the material is neither completely rustless nor stainless. Its outstanding feature is that under normal conditions it resists tarnishing influences to a remarkable degree.

South Yorkshire Coal Trade.—A larger tonnage of steam fuel is going into consumption in the local iron and steel trades now that work has been generally resumed, but as shipments are rather easier, gross requirements are not sufficient to afford full-time working at the pits. The reduced output of slacks resulting from the holiday stoppage has to some extent stiffened prices. Virtually the whole output of gas fuels is going inland on contract account. Blast-furnace coke is easier owing to the reduced demand for export. Householders are buying sparingly in anticipation of lower rates. Quotations:—Best branch hand-picked, 38*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 32*s.* 6*d.* to 34*s.*; Derbyshire best house coal, 28*s.* 6*d.* to 30*s.* 6*d.*; Derbyshire best large nuts, 27*s.* 6*s.* to 28*s.* 6*d.*; Derbyshire small nuts, 16*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 8*s.* to 9*s.* 6*d.*; smalls 2*s.* 6*d.* to 6*s.* 6*d.*

TECHNICAL INSTITUTIONS IN BIRMINGHAM.—Several technical institutions will simultaneously hold their annual conferences in Birmingham, from June 20 to 23. The Institution of Automobile Engineers will discuss matters affecting the motor industry, whilst the Municipal Electrical Association will hold a conference upon matters affecting their interests. The Institution of British Foundrymen is to discuss an important programme of foundry papers. Various visits to representative works have been arranged. To synchronise with the conference a Foundry Trades Exhibition has been organised in the Bingley Hall with Lord Weir as president. The exhibition will be open for 10 days. The organisation, so far as it deals with the Foundrymen's Conference, &c., is in the hands of Mr. Thomas Vickers, of the British Cast-Iron Research Association.

THE AUDOS MINE RESCUE APPARATUS.—In our report on the Proceedings of the Engineering Section of the British Association (ENGINEERING, October 21, 1921, page 508) we illustrated two recent English mine rescue apparatus, the one charged with a liquid air containing 60 per cent. of oxygen, the other, due to Professor Henry Briggs himself, who described the apparatus, charged with compressed oxygen. The one apparatus weighed complete 35 lb., the other 36 lb. The Audos apparatus of the Hanseatische Apparatbau-Gesellschaft, of Kiel, described in *Kali*, of March 1, by Mühlefeld, director of the Clausthal Mine Rescue Station, is recommended because it is considerably lighter in weight than the Dräger and Westphalia apparatus in use there, and because it leaves the chest completely free and allows the man free movement of the head and to work in a stooping position. There is no helmet; spectacles form part of the outfit. The apparatus is of the usual regenerative type; the rate of oxygen supply is automatically adjusted to the consumption; the apparatus was the only one of several tried about which the men did not complain. Yet nitrogen accumulates slowly in the course of service, the nitrogen being originally present in the oxygen or leaking into the apparatus, and the apparatus remains cumbrous. The Audos apparatus is made of various patterns for services of 1 hour, 2 hours and 3 hours. These weigh complete 11·7 kg., 12·50 kg. and 13·3 kg. (30·4 lb.).

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is within narrow limits, but output is fully absorbed by current contracts and occasional purchases. No. 1 and forge qualities continue exceedingly scarce, and supply of other grades is no more than is necessary for the moderate requirements. To customers North of the Tweed, makers agreed on quotations, for No. 3 is 96*s.* 6*d.* f.o.t. Grangemouth. To all other destinations at home and abroad f.o.t. makers' works, and f.o.b. Tees quotations stand: No. 1 and siliceous iron, 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 85*s.*; and mottled and white, 80*s.* Producers declare they incur loss on the foregoing figures, but they hope for early relief to the situation by substantial reduction in railway rates.

Hematite.—A moderate amount of business in hematite is reported. The tonnage of metal going into prompt local use is far from large owing to slackness in the steel trade, but foreign business shows some expansion, and includes further sales to Germany. Makers are keen to secure orders, but are most reluctant to lower quotations, which vary rather considerably. Whilst some producers are asking as much as 98*s.* 6*d.* for Nos. 1, 2 and 3 East Coast brands, both for home purposes and for despatch to foreign ports, purchasers report no difficulty in arranging business at 96*s.* 6*d.*

Foreign Ore.—New business in foreign ore is exceedingly small, but imports against old contracts are on quite a heavy scale. Though possibly less would be accepted best rubio is still put at 27*s.* c.i.f. Good Mediterranean ores are in the neighbourhood of 22*s.* c.i.f.

Coke.—Local consumers of blast-furnace coke complain considerably at the high prices they are compelled to pay for early delivery. Average Durham qualities are realising 28*s.* 6*d.* delivered, and even more, but there are reports of contracts over a period having been arranged on substantially lower terms.

Manufactured Iron and Steel.—Very unsatisfactory and discouraging accounts continue to be given of the various branches of the manufactured iron and steel industries. Steel works that are running are only partially employed, and there seems little prospect of the early re-start of establishments that are closed. Prices are weak, but the only quotable change is a 10*s.* drop in steel billets. Foreign orders can be placed at below the following quotations, which rule for home business:—Common iron bars, 12*l.*; iron rivets, 14*l.*; steel billets (soft), 7*l.*; steel billets (medium), 8*l.* 5*s.*; steel billets (hard), 8*l.* 15*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy sections of steel rails, 9*l.* 10*s.*; fish plates, 14*l.*; and corrugated galvanised sheets, 16*l.* 5*s.*

ELECTRICAL ENGINEERING SCHOLARSHIPS.—We are informed that the following scholarships have been awarded as a result of the recent entrance scholarship examination held at the Faraday House Electrical Engineering College: R. W. Griffin, 50 guineas per annum for two years in college and one in works; D. Moody, 50 guineas per annum for one year in college and one in works; W. Swindells, 30 guineas per annum for two years; B. K. Watts, 30 guineas for two years; J. W. Bailey and D. F. Glover, an entrance prize each of 20 guineas.

STANDARD SPECIFICATIONS FOR TRAMWAY RAILS AND FISHPLATES.—A revised report (No. 2, 1922) on "Tramway Rails and Fishplates," has recently been issued by the British Engineering Standards Association, and may be obtained for 1*s.* net, or post free 1*s.* 3*d.* from the Secretary, 28, Victoria-street, S.W. 1, or Messrs. Crosby, Lockwood and Son, Stationers' Hall-court, E.C. 4. The original report on this subject was published in 1903, an additional standard being added in 1911. In the present revision separate analyses are given for both Bessemer and open-hearth steels, a higher carbon content being adopted. Provision has also been made for added silicon in basic rails. The position of the test pieces is defined. The minimum tensile strength is raised to 45 tons, and various other changes have been introduced in order to keep abreast with progress and make the specification as widely serviceable as possible.

A SINGULAR RAILWAY ACCIDENT.—The report of the Ministry of Transport on the singular accident to two passenger trains on the London and North-Western Railway, on January 30, has just been issued. The case was investigated by Major G. L. Hall, and present peculiar features which fortunately are not common in railway experience. The accident, which resulted in one passenger being killed, and some 25 others injured was due to a step casting becoming detached from the tender of one train, and doing damage to both trains while in the act of passing one another. The damage was mainly to the coaching stock, as the casting on striking the ground seems to have rebounded to a height sufficient for it to break up the body work of the coaches at 7 ft. to 8 ft. above rail level, where it ripped off the sides of compartments and finally became embedded in a partition. The debris caused resulted in other damage to other vehicles. The casting measured approximately 3 ft. by 2 ft. 10 in., and weighed about 2 cwt. The engine had been reported several times for loose footsteps, but the fact does not appear to have been known. Major Hall suggested that means should be taken for bringing to the attention of some responsible official the fact that an engine is reported frequently for the same defect.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The past week has seen no change in the conditions ruling the Scottish steel trade, and everything seems well against any early improvement. Business is really getting from bad to worse, and on no hand can confidence be found. Buyers are keeping aloof from the market, and it is only the small odd lots which are keeping part of the plant moving. It is not only the home trade which is stagnant, but overseas markets are very similar and few export orders are being booked. For black sheets there is still a very poor demand, and the prospects are not bright. Current prices are unchanged and are as follow:—Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; sections, 10*l.* per ton; and sheets, 11*l.* 15*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The malleable iron trade of the West of Scotland continues lifeless, and little fresh business has recently been booked despite the easier price now asked by producers. When the last reduction was arranged it was thought that buying would improve, but so far there has been no increase in the demand. The price quoted for "crown" bars is still 11*l.* per ton, at Glasgow.

Scottish Pig-Iron Trade.—There has been no improvement in the state of the pig-iron trade of Scotland during the week, and consumers are not able to take up the whole of the output, with the result that stocks at makers' yards are accumulating. This condition is likely to continue until labour troubles all round get settled, which cannot now be far off. With the steel trade so quiet the demand for hematite iron is very poor, and to-day's price is 5*l.* 5*s.* delivered at the steel works. Foundry iron is quoted at 4*l.* 17*s.* 6*d.* per ton for No. 1, and 4*l.* 12*s.* 6*d.* per ton for No. 3, both at makers' works.

Shipyard Dispute.—A more hopeful turn has now taken place in the shipyard dispute as a result of the joint conference between the Negotiating Committee of the shipyard trade unions and the Committee of the Shipbuilding Employers' Federation. A basis of settlement has been reached and the men will ballot on the modified proposals of the employers, which will be recommended by the men's leaders. Briefly stated, the proposal is the withdrawal of 16*s.* 6*d.* of the 26*s.* 6*d.* war bonus in three instalments instead of two, namely:—10*s.* 6*d.* per week on resuming work; 3*s.* per week in the middle of May; and 3*s.* per week in the middle of June. There is every reason to believe that the ballot will result in accepting the new terms and that work in the shipyards will be restarted on an early date.

Nails Reduced in Price.—The price of steel nails and dog spikes has been reduced for export. The price of the latter for basis size, 4 in. by ¼ in., will now be 18*l.* 10*s.* per ton, less 2½ per cent. discount, f.o.b., in 2-ton lots.

SWANSEA MEETING OF THE INSTITUTE OF METALS.—The annual autumn meeting of the Institute of Metals will be held at Swansea on September 20 to 22. A ballot for the election of members and students desirous of participating in this and other meetings of the Institute will take place on July 13. Membership particulars can be obtained from the Secretary of the Institute of Metals, 36, Victoria-street, S.W. 1.

CORROSION OF CONDENSER TUBES.—A second and revised edition has just been issued by the Corrosion Research Committee, 36, Victoria-street, S.W. 1, of the valuable pamphlet entitled "Notes on the Corrosion and Protection of Condenser Tubes." The document, which is published at 2*s.* 8*d.* post free, is intended to be of service to manufacturers of tubes and condensing plant and to the engineers who use them. It is of an essentially practical character, and embodies the results of ten years' research The first edition of 1,000 copies was exhausted within a week of publication. The new edition contains much valuable additional matter.

WORKS CLOAK ROOMS.—Generally speaking, we are rather behindhand in this country in the provision of washing and cloak room accommodation in engineering works. In saying this we are not losing sight of the many cases in which admirable and adequate provision of this kind has been made. The British employee has, however, in many trades been quite satisfied to defer cleaning up till he reaches his home, and does not evince the desire, which is to be noticed in some other countries, to leave behind at the works all marks of toil, together with working clothes. By degrees, however, a change is taking place. In dangerous trades provision for washing and changing is now compulsory and generally is, we believe, appreciated. In others there is a desire to live better, and the ideas of the younger generation are gradually gaining ascendency so that more advantage will steadily be taken of facilities provided as years pass. There is always, too, the question of extra coats and wraps, and it is now admitted that better provision should be made for these than that they should be allowed to hang on the shop walls, or be packed away under benches. The degree of elaborateness of cloak-room and other provisions will vary considerably with the works, and any owners wanting information covering a wide range from simple to more complicated schemes will find a good deal to interest them in a pamphlet just issued by the Home Office. This is the Welfare Pamphlet No. 8, and deals with cloak rooms, washing facilities, drinking water and sanitary accommodation in factories and workshops. It is amply illustrated and may be obtained through the usual channels at the cost of 1*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—With work in the coalfield more regular and a prospect of a small advance in the general wage rates the miners' leaders are becoming restive. The Executive Council of the South Wales Miners' Federation have convened a delegate conference to consider (1) the continued refusal of some colliery owners to give preference of work to men formerly in their employ; (2) irregular reductions in wages, and (3) the methods to be adopted to increase the membership of the Federation and the desire expressed for some alteration in the constitution of the Federation. Meanwhile, though there is no general break in coal market prices, the undertone is somewhat weaker. This is especially so in respect to Monmouthshires for Black Vein and Western Valleys are now obtainable at 27*s.* 6*d.*, against 28*s.* to 28*s.* 6*d.* a week ago, with Eastern Valleys round 27*s.* Best and second Admiralties, however, remain steady, with the former round 28*s.* 9*d.* and the latter 28*s.* 6*d.* Best drys are round 27*s.* 6*d.*, with ordinaries from 24*s.* 6*d.* to 25*s.*, while best steam smalls are irregular from 19*s.* to 20*s.*, with ordinaries from 17*s.* 6*d.* to 18*s.* 6*d.* Cargo exports in the past week totalled 476,000 tons, or 105,000 tons more than in the previous six days. After prolonged negotiations the coal trimmers and tippers have agreed to extend their working shifts by half an hour during which time meals will be taken, instead of at opportune times, as has been the case during the past twelve months. It is estimated that the fixing of a definite meal time during the two continuous day shifts of 8 hours each, exclusive of the meal time, will enable the railway companies to facilitate the marshalling and clearance of wagons so that an extra 3,000,000 tons of coal can be shipped during the year.

Shipowning at Cardiff.—According to a list compiled by the Cardiff District Shipping Federation there are 124 Cardiff firms controlling 373 vessels of approximately 937,000 gross tons—compared with twelve months earlier this represents a decrease of 50 vessels and of 27,000 in tonnage. The position of the leading firms in the latest list, and a year earlier, is shown below:—

Firm.	March, 1921.		March, 1922.	
	Vessels.	Gross Tons.	Vessels.	Gross Tons.
Sir W. R. Smith and Sons ..	22	116,479	36	180,177
E. Edwards and Sons (Western Counties Co.) ..	24	93,676	—	—
Williams Bros.	11	80,229	16	51,839
Gould Steamships	12	53,399	11	48,261
Merrett Bros.	12	27,506	21	47,095
Evan Thomas, Radcliffe ..	10	46,926	10	46,926
Harrison, Sons and Co. ..	18	36,192	25	44,997
Jenkins, Richards and Evans (Maindy Shipping Co.) ..	12	31,379	—	—

Sir W. R. Smith, Bart, the head of the St. Just Steamship Company, the Leeds Shipping Company and the Cornborough Line, Limited, easily maintains his position as the premier shipowner in South Wales, while the Western Counties Shipping Company, which a year ago was second in the list, and the Maindy Shipping Company, have disappeared as a result of the enormous depreciation which has taken place in shipping values.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—The sessional examinations of this Institute take place on June 19, 20 and 21, and will be held in London, Manchester, Birmingham, Sheffield, Glasgow and Bristol. Application should be made on Form C, obtainable from the Secretary, 38, Grosvenor Gardens, at least 21 days before the date of examination.

MOTOR TAXATION.—The Ministry of Transport have issued a table showing the number of motor and other licences issued from December 1, 1921, to February 28, 1922. From this it is seen that the annual motor licences numbered 574,490 and the quarterly and part-year motor licences were 95,040, for a total of 7,555,287*l.* The horse-drawn licences numbered 175,971 annual and 68 part-year, yielding 137,707*l.* Miscellaneous receipts amounted to 63,660*l.*, giving a total of 7,756,654*l.*

GERMAN POTASH DEPOSITS.—We read in the *Revue Universelle des Mines* that according to a report recently issued by the Kalisyndikat the extraction of potash salts in Germany greatly increased during the year 1920. From 7,772,036 tons in 1919, the output in 1920 rose to 11,386,437 tons, an increase of 50 per cent. Notwithstanding the loss to Germany of the Alsatian potash deposits (see page 206 *ante*), the output is close upon the 1913 figure, which was 11,607,510 tons, the highest figure hitherto reached. The figure for 1912 was 11,070,015 tons.

LONDON TRANSPORT CONGRESS.—A congress of the Institute of Transport will be held in London from May 17 to 20, at the Institution of Civil Engineers. This is the first congress held in London at which all branches of transport will be represented. The proceedings will comprise the reading and discussion of papers. Delegates from the British Dominions, United States of America and the Continent will attend. The headquarters of the congress will be at the Hotel Metropole, Northumberland-avenue. Advance copies of papers to be read can be obtained upon application to Mr. H. E. Blain, Hon. Secretary, 15, Savoy-street, Victoria Embankment, W.C. 2.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 28, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W., "An Account of Some Experiments on the Action of Cutting Tools," by Professor E. G. Coker, D.Sc., F.R.S., of London, Member, and Mr. K. C. Chakko, D.Sc.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, April 28, at 7.30 p.m., in the Applied Science Department, The University, St. George's-square. Paper on "Why Non-Ferrous Metals Crack," by Mr. W. H. Hatfield, D.Met.

THE SOCIETY OF ENGINEERS.—Monday, May 1, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House. A paper will be read at 5.30 p.m., on "The Testing of Small Electrical Plant," by Dr. C. V. Drysdale, O.B.E., D.Sc., F.R.S.E., M.I.E.E. (being Part II of his paper of the same title read before the Society on March 6, 1922).

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 2, at 6 p.m., the Twenty-Eighth James Forrest Lecture, entitled "Some Post-War Problems of Transport," by Sir John Audley Frederick Aspinall, Past-President Inst. C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, May 3, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "Short-Wave Directional Wireless" (illustrated by experiments), by Mr. C. S. Franklin.

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 3, at 8 p.m.: Ordinary Meeting, "The Production of Titanium Oxide, and its Use as a Paint Material," by Mr. Noel Heaton, B.Sc. Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will preside. Friday, May 5, at 4.30 p.m.: Dominions and Colonies and Indian Sections (Joint Meeting), "Imperial Wireless Communication," by Professor W. H. Eccles, D.Sc., F.R.S., Vice-Chairman of the Wireless Telegraphy Commission. The Right Hon. Viscount Burnham, C.H., President of the Empire Press Union, will preside.

THE IRON AND STEEL INSTITUTE.—Thursday, May 4, at 10.30 a.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1. Annual Meeting. Presidential Address by Mr. Francis Samuelson. Papers to be read and discussed: "British Siemens Furnace Practice," by Mr. F. Clements; "Notes on Blast Furnace Filling," by Mr. D. E. Roberts; "Effect of Oxidising Gases at Low Pressures on Heated Iron," by Mr. H. C. H. Carpenter and Miss C. F. Elam; "Hydrogen Decarburisation of Carbon Steels, with Notes on Related Phenomena," by Mr. C. R. Austen; "Influence of Dissolved Oxides on Carburising and Hardening Qualities of Steel," by Mr. E. W. Ehn. The annual dinner will be held in the Grand Hall of the Connaught Rooms, Great Queen-street, W.C., at 7.15 for 7.30 p.m. Friday, May 5, at 10.30 a.m.: "Recent Developments in Power Production," by Mr. D. Selby-Bigge; "X-Ray Studies on the Crystal Structure of Steel," by Mr. A. Westgren and Mr. G. Phragmen; "The Inner Structure of the Pearlite Grain," by Mr. N. T. Belaiew; "Formation of Globular Pearlite," by Mr. J. H. Whiteley; "On Delayed Crystallisation in the Carbon Steels; the Formation of Pearlite, Troostite and Martensite," by Mr. A. F. Hallimond; "On the Constitutional Diagram of the Iron-Carbon System, based on Recent Investigations," by Mr. K. Honda; "On the Stepped A1 Transformation in Carbon Steel during Rapid Cooling," by Mr. K. Honda and Mr. T. Kikuta; "On the Heat Transformation of Austenite to Martensite, and of Martensite to Pearlite," by Mr. N. Yamada.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, May 4, at 7.15 p.m., at the Engineers' Club, 39, Coventry-street, W. 1. "Comparison between Superheated and Non-Superheated Tank Engines," by Mr. J. A. Hookham, Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 5, at 9 p.m., a discourse will be delivered by Mr. Michael Grabham, M.D., F.R.C.P. The subject is "Biological Studies in Madeira." Afternoon Lectures, at 3 p.m.: Tuesday, May 2, Sir Arthur Keith, M.D., L.LD., F.R.S., M.R.I., Fullerian Professor of Physiology, R.I., on "Anthropological Problems of the British Empire: Series II.—Racial Problems of Africa" (Lecture II); Thursday, May 4, Mr. Edwin H. Barton, D.Sc., F.R.S., on "(II) A Syntonic Hypothesis of Colour Vision"; Saturday, May 6, Professor D. H. MacGregor, M.A., M.C., on "Industrial Relationships: (II) The Problem of Structure."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 5, at 8 p.m., at Caxton Hall. Lecturette, "Casting Under Steam Pressure," by Mr. E. N. Ching. (Demonstrations.)

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Saturday, May 6, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Informal Discussion Evening to discuss "Uniflow *v.* Multiple Expansion Steam Engines."

TRANSMUTATION OF THE ELEMENTS.—Sir Ernest Rutherford, F.R.S., who has recently been elected President of the British Association, is to deliver the twelfth annual May lecture before the Institute of Metals at 8 p.m. on Wednesday next, May 3. The work which has lately been done concerning the transmutation of elements lends especial interest to the discourse, the subject of which is "The Relation of the Elements." Cards of invitation to the lecture are obtainable from Mr. G. Shaw Scott, M.Sc., Secretary, the Institute of Metals, 36, Victoria-street, Westminster.

VERTICAL GRINDING MACHINE WITH 6-FT. ROTARY TABLE.

CONSTRUCTED BY THE LUMSDEN MACHINE COMPANY, LIMITED, ENGINEERS, GATESHEAD.

(*For Description, see Page* 520.)

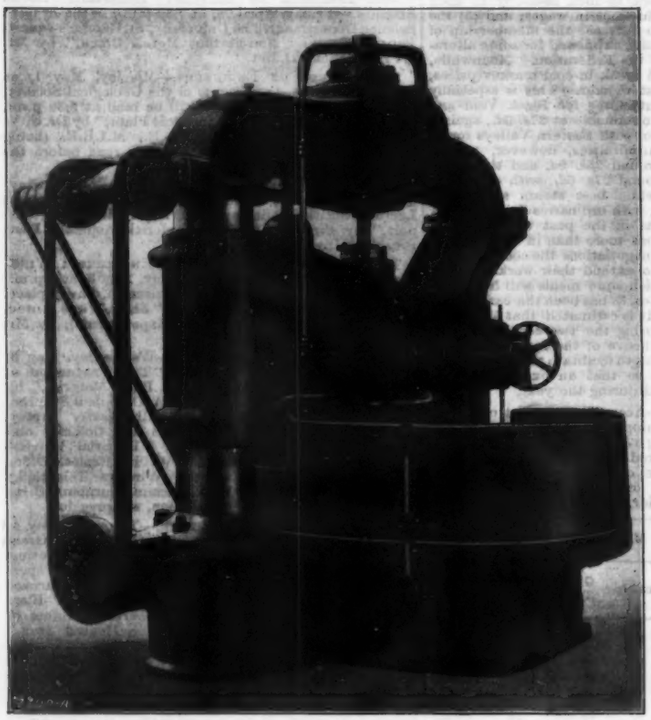


FIG. 4.

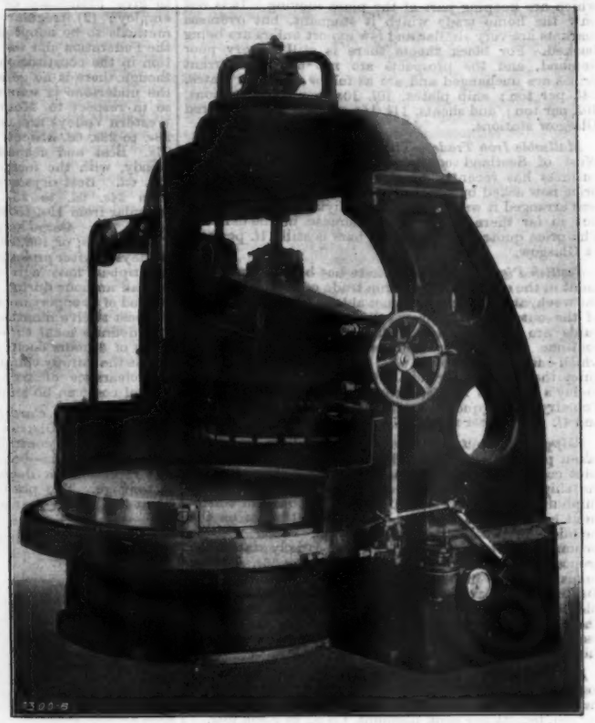


FIG. 5.

FIG. 6.

FIG. 7.

FIG. 9.

FIG. 10.

Fig. 8.

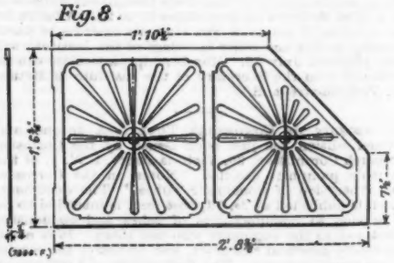
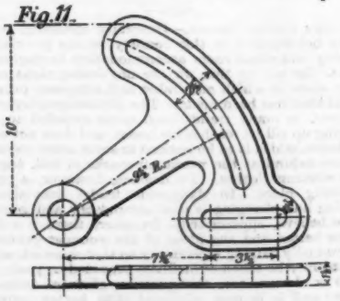


Fig. 11.



BELGIAN INTERNATIONAL SCIENTIFIC CONGRESS.—With reference to our announcement under the same heading on page 216 *ante*, we are informed that this congress has been postponed one week; it will open on June 18, instead of on June 11, as formerly announced.

THE INSTITUTION OF MECHANICAL ENGINEERS' PROCEEDINGS.—The volume of the Institution's Proceedings for the second part of 1921, just issued, deals with the form of a conference on the thermal efficiency of heat power plants. The introductory papers and discussion are printed in abridged form, and a portrait group of the American engineers who formed a delegation to the conference from the American engineering societies is reproduced. The volume also includes a summary of the Eleventh Report of the Alloys Research Committee, reprints of papers and discussions on the "Machinery of Floating Docks," "Conveying and Elevating Machinery," "Grain Discharge by Pneumatic Elevators," and the Thomas Hawksley Lecture on "Power Transmission by Oil."

ENGINEERING.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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ENGINEERING.

FRIDAY, APRIL 28, 1922.

FAILURE BY FATIGUE.

IN a lecture delivered to the Royal Institution in 1914, the late Lord Rayleigh quoted some exasperated experimentalist to the effect that the classical theory of hydrodynamics as developed by Euler and Lagrange, was a science which had no connection with the actual behaviour of real fluids. The practical engineer could find, in the records of experience, grounds for an equally unrestrained indictment of the mathematical theory of elasticity. In each case the criticism, though not wholly without foundation is too sweeping in character, and both mathematical theories have proved of very considerable service to the practician, in spite of the fact that the ideal materials to which alone they apply without restriction, remain mere figments of the imagination never encountered within the cosmos as we know it. It is this fortunate fact which made it possible for Professor Bridgman, of Harvard, to carry out his highly interesting and instructive experiments with intense hydraulic pressures. Had the postulates of the mathematical theory continued to hold good, his containing vessels would have burst, and it is this same failure of the foundations of the theory which has been responsible for the practical success of the thin arched dams erected in Australia and elsewhere. Nevertheless the theory is indispensable to the structural designer, just as a knowledge of the fundamental principles of hydrodynamics is to the engineer who has to concern himself with the behaviour of real fluids.

It was inevitable in the very nature of things, that the successful development of stress analysis during the nineteenth century should have led those versed in it to under-estimate the importance of the empirical factor involved in the fixation of working stresses. The late M. Gustave Canet, in his presidential address to the Junior Institution of engineers in 1908, confessed that the reverence which as a young man he possessed for mathematical formulas had been greatly modified by thirty years' experience. Other engineers who have left College with a profound faith in the sufficiency of such formulas have been similarly disillusioned.

Fairbairn seems to have been the first to state quite definitely that the permissible working stress on an iron structure was not a fixed quantity, but varied with the character of the loading. This conclusion was at the outset merely based on observation and experience, and whilst we now see in it evidence of Fairbairn's insight and intuition, it is not remarkable that the Board of Trade representatives of his day entered a demurrer, which led to the earliest experiments on the fatigue of materials first by Fairbairn himself and subsequently by Wöhler. Although some explanation of Fairbairn's and Wöhler's results had been supplied in anticipation by James Thomson's demonstration of the fact that the raising of the tension elastic limit of a material by stretching it, involves a lowering of the compression limit, the reality of fatigue continued to be disputed even after Thomson's conclusions had been confirmed by the elaborate experiments of Bauschinger. Bridge engineers in particular were prone to attribute to the effects of impact, the necessity of adopting lower unit stresses in proportioning structures intended to carry relatively high loads. It is probable that this view was less firmly held than one would be justified in believing from the wording of certain clauses in standard specifications for bridge work. However, whether right or wrong the inclusion of provisions for impact stresses did constitute a definite recognition of the fact that the safe limit of stress was a function not merely of the nature of the material adopted, but also of the use to which it was to be put.

In other branches of engineering the reality of fatigue phenomena has been less in question: and a very interesting review of the whole matter was drawn up in 1919 by the United States National Research Council, preparatory to a further experimental inquiry into the subject.

Whatever views may be held as to the mechanism of failure by fatigue, all agree that the safe permissible stress is a function of the number of times it is repeated. In this regard conditions have changed enormously since the days of the pioneers. The old engine which was operated at the Watt centenary celebration of 1919 made 14 strokes per minute. Nowadays we have steam turbines of 20,000 h.p. running at 3,000 r.p.m. With these early engines the question of failure by fatigue can hardly have arisen, since purely commercial considerations, generally consigned them to the scrap heap before they had made many millions of strokes. On the other hand, the American Research Council estimate that a steam turbine may make 15,000,000,000 revolutions during its working life, and a steam engine 1,000,000,000. This latter figure probably refers to land practice, and to high-speed engines, and can hardly be attained in sea service. Car axles are attributed a life of 360,000,000 revolutions; whilst main bridge members are only called upon to undergo 2,000,000 repetitions of stress. It is of interest to note that according to this estimate rails are only subjected in their lifetime to half a million repetitions of engine wheel loads, but to 15,000,000 repetitions of the car wheel loads. These figures are low, and as the steel used is of a fairly hard type, it is evident that the life is determined by the abrasion of the top table rather than by the resistance of the rail to bending, a view which is confirmed by the relative infrequency of rail fractures.

The enormous number of repetitions of stress which a turbine shaft is called upon to endure during its life is no doubt responsible for the very high factor of safety which experience has shown to be necessary in proportioning such shafts. Some designers take this factor as 20. Similarly it seems reasonable to conclude, that the fact that Lloyd's rules for marine engine crankshafts proved unsatisfactory when adopted as the basis of design for high-speed engines, is also to be attributed to the greater liability of the latter to fatigue from the many repetitions of the stresses.

When the phenomena of fatigue first began to be generally recognised the belief was common that the

long-continued vibration caused the material to crystallise, and the older text books made frequent references to the fibrous character of surfaces which had failed under a steady stress and the obviously crystalline constitution of the surface exposed by a fracture due to fatigue. Now, however, it is known, that even in typically fibrous materials, the ultimate constitution is really crystalline, and the characteristic appearance of fatigue fractures, is attributed to the progressive character of the failure. To a first rough approximation a specimen pulled apart in a tensile test gives way like the Deacon's Shay, "All at once and nothing first," whilst fatigue fractures start in a small local failure, which spreads gradually from crystal to crystal, as the stresses are repeated, until final failure occurs.

The great drawback to experiments on the resistence of metals to repeated stresses has been the time required to complete them, and many suggestions have been made with a view to obtaining reliable results within a reasonable time. As the result of investigations carried out at the University of Illinois by Professor H. F. Moore and Professor J. B. Kommers, on behalf of the National Research Council and others, some interesting conclusions on this head have been reached. The results observed indicated that in all cases an indication of the endurance limit of a material could be obtained, with experiments not extending beyond 10,000,000 repetitions of stress. The observers relied for the most part on rotating bar tests which have the advantage that very high rates of alternation of stress can be employed without risk of errors from inertia effects. The specimens were subjected to a bending moment which was uniform over a length of about 3 in. It was found necessary to have this portion of the beam of much smaller diameter than the remainder, since without this precaution fracture always occurred at the collets, where the loads which produced the uniform bending moment were applied. Moreover, in making the change of section, fillets of very large radius were found essential. Thus the main body of the bar being 0·4 in. in diameter and the reduced section 0·3 in. in diameter, a radius of ½ in. at the junction was proved to be too small. Ultimately this reduced section was made as one continuous curve from end to end of 9·85 in. radius, which gave a practically parallel section about ½ in. long at the mid-point.

A notable point brought out in these experiments was that surface finish had an important bearing on the capacity to withstand alternating stresses. Rough-turned specimens show 20 per cent. less endurance than polished ones. Test-pieces finished by grinding, though better than if merely machined, were still distinctly inferior to those with polished surfaces. There was, however, no material difference between specimens finished with rouge and those polished with emery cloth in the usual way.

Other fatigue experiments were made under reversed torsion, and by bending plate specimens to and fro, but a more expensive type of apparatus was needed for these, and it was necessary to adopt much lower rates of alternations in order to avoid trouble from inertia effects.†

One interesting result was that the ultimate strength of the material was a somewhat more reliable index of its endurance than was the elastic limit. The Brinell test was, however, still better; whilst the notched bar tests were unsatisfactory in this regard. Of course, in this connection it must be borne in mind that, in practice, tests are made with different objects. For the most part the suitability of a material for a given purpose is estimated from the results of practical experience with it, and the purchaser accordingly merely requires some simple and rapid test to ensure that he is being supplied with the material specified, and that this is of uniform quality. Undoubtedly the notched bar test provides a very drastic test of this latter quality, even if as appears from the Illinois experiments, it does not afford any direct measure of the fatigue strength of a material. In this connection mention may be made of a very ingenious application of the Hughes' induction balance to detect lack of uniformity in steel or iron bars. The apparatus described in the report is due to Dr. C. W. Burrows, of New York.

As regards endurance, a distinction must apparently be drawn between uniformity and homogeneity. The former term implies the absence of local variations, whilst homogeneous materials consist of a single phase. Two of the materials tested at Illinois approximated to this latter condition. The one containing but 0·02 per cent of carbon was almost pure ferrite and the other, with 0·93 of carbon, almost pure pearlite. Both materials, in the rotating bar tests, yielded results which were not in accord with the tests made on other materials. The ferrite bars showed an endurance limit in excess of the yield points of the material as tested in tension and compression, and with the pearlite bar these limits were closely approached. In all other cases the endurance limit was well below the yield-points of the material.

The first observation does not seem to admit of any very direct explanation. The observers themselves suggest that the effect is analogous to what happens when a solid iron or steel bar is subjected to a transverse test. In that case, as is well known, the fibre stress at failure as calculated from the usual theory, is commonly far in excess of the tensile strength of the material, a result which was explained by Considére as due to the large stretch which iron and steel take when the elastic limit is passed. The over-strained fibres at the surface are thus able to transfer to their less strained neighbours much of their overload. It appears difficult, however, to realise how this can occur with a bar subject to alternating stresses, and the matter evidently requires further investigation.

As already stated the observers came to the conclusion that the endurance limit of ferrous materials can be determined from experiments not extending beyond 10,000,000 repetitions of the stress. But even 10,000,000 repetitions of the stress require several days to complete, and a less tedious plan would be highly advantageous. This appears to be afforded by Mr. Stromeyer's method, which was described in our issue of September 10, 1915, page 259. It is based upon the fact pointed out by Lord Kelvin in 1855 that a specimen is cooled by stretching it within its elastic limit and heated by compressing it. On the other hand, any permanent distortion always heats the bar. Hence if subjected to an alternating stress, so long as the internal work done is wholly elastic the rise of temperature produced by compression will be annulled by the reduction of temperature due to tension, and the mean temperature will remain unchanged. So soon, however, as permanent changes are produced within the metal there will be a rise of temperature. Modern electrical methods of measurement make it easy to observe extremely small temperature effects, and in the modification of Mr. Stromeyer's apparatus adopted by Messrs. Putnam and Harsch in the Illinois researches, a rise of 0·003 deg. C. could be detected. Experiments made with this apparatus proved very promising, and it is claimed that with it the endurance limit of a material could be determined with fair accuracy within a few hours.

It has sometimes been asserted in the past that once a material has been strained beyond its elastic limit it was ruined, a contention which was maintained in spite of the fact that plates for boiler shells are bent to form cold, and appear none the weaker for this drastic treatment. In this connection some of the experiments made at Illinois are of special interest. Suppose the endurance limit of a material, under alternating stress, has been determined, that is to say, the stress of which it will endure an unlimited number of repetitions. What will be the effect of submitting it at the outset to a limited number of higher stresses? The Illinois observers conclude that a 38 per cent. over stress applied 100 times does not permanently injure the material, but a 35 per cent. over stress applied 1,000 times did apparently reduce the endurance by 4 per cent. This fact is obviously one of great interest, as it indicates that an occasional temporary overload of a machine part or of a bridge member is of no practical importance. This conclusion may possibly lead to a revision of current ideas as to the importance of temperature stresses in bridge work. It is, moreover, noteworthy that high carbon steels were found to suffer more from occasional overloads, than the softer structural materials.

† Detailed particulars of the whole investigation will be found in *Bulletin No. 124 of the Engineering Experiment Station of the University of Illinois*. Price 95 cents. European agents: Chapman and Hall, Limited, London.

LOW TEMPERATURE CARBONISATION.

IN view of the steadily increasing importance of liquid fuels, it is certainly undesirable that we should as a nation be so dependent on overseas sources of supply. According to Mr. D. Brownlie, the United States control 80 per cent. of the world's supplies. The British Empire produces but 2½ per cent. of the total and controls but 5 per cent., a fact which renders curious the professed concern of the oil interests of America at our efforts to enlarge our sources of supply. Mr. Brownlie states that our imports of petrol amount to 200,000,000 galls. per annum, but that if the 150,000,000 tons of coal, now wastefully used in the raw state, were treated by low temperature carbonisation, we should obtain from it not less than 500,000,000 galls. of motor spirit and 75,000,000 barrels of oil, a condition of things which would render us independent of outside sources. That such a consummation is in itself eminently desirable, hardly admits of argument, but the question arises as to whether the scheme is commercially feasible. This matter was the subject of discussion in several papers recently read before the South Wales Institute of Engineers, and from one of these we have quoted the figures reproduced above. Most of the papers described different patented plans of effecting low temperature carbonisation, and all claimed success. The communication made at the same meeting on behalf of the fuel research board by Dr. C. H. Lander was however much less sanguine. Success appears to depend on the possibility of selling the coke produced at a price which will fully cover the cost of the raw coal used. From each ton of this raw coal some 14½ galls. of crude oils, worth 5*d*. per gall. can be obtained, in addition to from 3,000 cub. ft. to 3,500 cub. ft. of high quality gas which gas undertakers could profitably buy at 4*d*. per therm. From the oil and the gas the receipts per ton of raw coal should thus amount to about 15*s*. and if the 14 cwt. of coke simultaneously produced can be sold for as much as it costs to buy the ton of coal. Mr. Lander thinks that commercial success may be possible. One drawback to this scheme is that the coke requires handling and necessitates the same expensive system of transport to the consumer as is now used for coal. In some cases, too, low temperature coke has proved brittle and weak and thus bears handling badly. Nevertheless, it appears to be generally admitted that for domestic heating purposes it is superior to coal. It lights as easily, burns without smoke, and more of the heat generated by combustion passes into a room than is usual with ordinary coal fires. If 14 cwt. of this coke can be made in domestic heating, to do the work of 1 ton of coal, the prospect of its general adoption is fair, but if a special grate or special skill is required for burning it efficiently, the outlook is much less promising, although its cleanliness as compared with coal would no doubt ensure it a certain market even at some increase in total costs.

Perhaps, however, the most interesting paper presented to the meeting was one in which the new practice of the Power Gas Corporation is described. The Mond gas, produced until recently, yielded per ton of coal about 135,000 cub. ft. of gas, having a net calorific value of 140 B.Th.U.'s per cubic foot; 85 lb. to 95 lb. of sulphate of ammonia were also obtained from each ton of coal gas consumed. The process involved the passage of 2½ lb. of steam through the producers for each 1 lb. of fuel gasified, and of this steam only about one-third was decomposed in the producer, the remainder passing away with the gas at a temperature of about 500 deg. C. About ¾ lb. of this waste steam was recovered and passed again through the producer, but the remainder had to be provided from an outside source. Owing to the recent increases in the cost of labour, fuel and acid, it became necessary to cheapen methods of production, and by the process worked out by Messrs. Beswick and Rambush the economy and efficiency has been greatly improved. The steam required is now only

1 ton per ton of coal gasified and about the whole of it is decomposed. The gas has a net calorific value of 178 B.Th.U. and contains a very much smaller percentage of carbon dioxide than formerly. A typical analysis is as follows:—CO_2, 8·3 per cent.; CO, 21·0 per cent.; H_2, 20·5 per cent.; CH_4, 8·3 per cent.; N_2, 45·3 per cent.

It would be of interest to know whether this gas can be applied to lighting purposes. The original Mond gas could not, as it contained so large a proportion of CO_2 which cooled the flame. No doubt the proportion of carbon monoxide in the new gas is somewhat high, but it is not in excess of that in some of the gas supplied in America for domestic purposes. An important point is that the whole of the fuel is consumed, and there is no coke to be got rid of by expensive cartage. The tar produced amounts to from 15 gall. to 24 galls. per ton and contains up to 75 per cent. of oil, and is suitable for the manufacture of disinfectants and for crude oil firing. The amount of sulphate of ammonia obtained is about the same as with the older process. The plant required occupies much less space, and can take overloads for long periods of time.

THE SITUATION IN THE ENGINEERING AND SHIPBUILDING TRADES.

THE dispute in the engineering industry reached another stage on Tuesday, when the suspension of the lock-out notices affecting the members of the 47 trade unions other than the Amalgamated Engineering Union was terminated. The lock-out will begin on May 3. There is apparently no difference between the employers and the trade unions on the general principle that the employers should have the right to manage their establishments and the trade unions should have the right to exercise the proper functions of trade unions; but when they met to adjust a set of working conditions they found themselves at variance from the outset as to the practical application of the principle. The employers are willing that before any material change is made in the working conditions of any establishment ten days' notice of the proposed change is to be given to the workers directly concerned, in order that there may be an opportunity for discussion of the matter between the parties or their representatives. If they cannot agree on it during the ten days, the management may put the change in force, but the unions may proceed to further discussion of it in conferences with the employers' representatives in accordance with the "Provisions for Avoiding Disputes." The management are, however, to be bound to give notice only of proposed changes which they consider material, but the unions maintain in effect that it is the workers who are to judge of this. They claim that even if only one man in the establishment considers the proposed change to be material, the ten days' notice must be given before the change can be made. The employers say rightly that this would deprive them of the management of their works, and they refused—as they have done all along—to surrender the management of the works to the unions, and thereupon the negotiations broke down.

In the meantime an informal effort was made by the Amalgamated Engineering Union to find a basis of discussion with the engineering employers, but this also broke down. The negotiations having failed, the unions appear to be pressing for the constitution of a Court of Inquiry under the Industrial Courts Act. Whether this would lead to any good result or not we do not know, but one thing seems clear, the employers have nothing to fear from such an inquiry.

The Employers' Federation, in a letter to the Amalgamated Engineering Union, state that their committee have been forced to the conclusion that political motives have been the real cause of the present difficulty, and that it may, at an early date, be necessary for the committee to consider whether, in the interests of the workpeople, the employers and the industry, it would not be well for the employers to intimate generally that employment would be available for workpeople who are prepared to enter into individual agreements with the employers on the questions at issue. The seriousness of such a communication, and the possible effects of such a step, must be obvious to all.

In contrast to the grave position in the engineering industry, it is satisfactory that the prolonged negotiations between the Shipbuilding Employers' Federation and the Negotiating Committee of the Shipbuilding Trade Unions' Federation have resulted in an agreement upon a basis of settlement which the trade unions are to recommend their members to accept. Under a provisional agreement which has just been reached the men are to resume work at a reduction of 10s. 6d. a week, to be followed by two further reductions of 3s. each at intervals of about four weeks. In the interests of all parties we hope that the ballot will be in favour of the acceptance of these terms.

LONG-DISTANCE RADIOTELEGRAPHY.

THE remarkable development of radiotelegraphy during the war, facilitated by the temporary disregard of financial considerations, owed its initiation mainly to the recognition, in 1913, of the potentialities of the oscillating three-electrode or triode valve of de Forest, known also as the audion or electron tube. Up till 1914 the long-distance service was somewhat uncertain, and the ranges were limited rather by the sensitiveness of the receivers and detecting apparatus than by the transmitting power. Spark transmission by damped waves was mostly in use, both on board ship and in the high-power stations. The Poulsen arc of 1908, as well as the special high-frequency alternators of later construction, gave continuous undamped waves that rendered the reduction of antennæ dimensions possible and removed the restriction to which the wave-lengths to be used were so far submitted, As the wave-length increases, in other words, as the wave-frequency is diminished, the duration of the wave-trains for a given decrement becomes greater and the successive wave-trains are apt to overlap, making the signals indistinct. For telephone reception Poulsen had to cut up his train of continuous waves, and he did this by placing a "ticker" in the telephone circuit; the notes thus produced were not musical, however, and not easily distinguished from atmospheric and induction disturbances, the great enemies of radiotelegraphy.

The beat method for the reception of continuous waves, on which we now rely, we see from a lecture delivered before the Franklin Institute by Dr. L. W. Austin, head of the United States Naval Research Laboratory, Washington, was suggested by Tesla in a series of lectures in which he outlined the principles of a complete system of radiotelegraphy years before Marconi experimented with Hertz waves. Tesla proposed to use the beats of audible frequency between two systems of waves both sent out from the transmitting end. Later the second wave system was generated at the receiving station, and the way in which this can be done with the aid of the triode valve was indicated at the same time by E. H. Armstrong, in America, by A. Meissner in Germany, and by H. J. Round in England. The advantages of the beat method are that the receiver can adapt the note of the signal to his ear by adjusting the frequency of the local oscillations, that hence only waves of the same frequency would interfere with him, and that atmospheric disturbances are easily distinguished as such. As transmitters, that is for the production of high-frequency oscillations, the valves answer well for moderate powers, but are so far little used in high-power stations, though the arrangement of several valves in cascade admits of increasing the power in geometrical progression. These valves have a high efficiency and flexibility as to wave-length and they give pure notes; but their upkeep is costly, the elimination of the higher harmonics is difficult, and valves of outputs exceeding 8 kw. are, as yet, hardly commercial. The valves are, however, said to give fullest satisfaction on the Clifden-Nova Scotia service of Marconi's Company. The old arc method is still much used because it is low in initial cost and simple and cheap in manipulation, though of low overall efficiency. The high-frequency alternators are expensive and delicate, but they also have their advantages. The chief alternators are the Alexanderson machine of the American Radio-Corporation, the French Latour alternator, and the Telefunken alternator which differs from the others by having fewer poles and lower speed, stepping up the frequency by means of "doublers."

The antennæ ground resistance is one of the most unsatisfactory features of powerful transmitting plants. At Annapolis 40,000 dols. are annually spent upon power, the actual radiation-power efficiency attained being only 4·1 per cent. Various proposals have been tried to obliterate this ground resistance. Austin considers Meissner's (Telefunken Gesellschaft) idea as most promising; he buries a system of wires under the antennæ in such a way that the amount of current collected in each ground unit is proportional to the strength of the field of the antennæ in the given position of the unit; but there is little experience so far. Atmospheric disturbances, especially in daylight, which are held responsible for "freaks," occasional exceptionally bad or also good services, remain, however, the most formidable trouble. Closed coil antennæ or buried wires offer advantages over aerials. But they are not exempt from atmospheric disturbances, which are very curious in many respects. At Goat Island, San Francisco, and at North Island, near San Diego, the disturbances always come from one direction. The partial immunity does not extend to other parts of California, however, and seems to be almost unique in fact, though preferential good directions are known. Annapolis, *e.g.*, radiates best to the south, even down to Buenos Ayres, over 4,000 miles away, possibly because the salt water of Chesapeake Bay acts as a guide in that direction.

On the other hand, the transmitting station of Cayey seems to be very unfortunately situated, being surrounded by hills in the interior of Porto Rico. The Island of Java has sometimes been able to communicate with Amersfort in the Netherlands, 6,100 nautical miles away, with small power and waves of only 5,000 m., though the Java antennæ is stretched over a gorge, 3,000 ft. deep, in the Malabar mountains. Again, the French cruiser Aldebaran, in 1920, kept in touch with Lyons and Nantes in daylight as far as Madagascar and Réunion, possibly because the waters of the Red Sea facilitated transmission whilst the deserts of Africa and Arabia did not help when the ship steamed further east, to Australia and Tahiti. Aeroplanes, it is often said, know by the strengthening of their signals when they approach a river estuary in the direction of the sending station. Our readers will remember the work on atmospheric disturbances done by the British Association Committee on Radiotelegraphic Investigations, of which Professor W. H. Eccles gave an account at the Bournemouth meeting (see ENGINEERING, October 10, 1919, page 468); the working of the valves was discussed at length on that occasion. The Committee subsequently decided to hand over his task to the newly-formed International Union of Scientific Radiotelegraphy; transference is now taking place, and the new body is, in fact, already at work, Dr. Eccles informs us.

The biggest radiotelegraphic station in existence is the Lafayette station near Bordeaux, built by the American Navy during the war; the Marconi antennæ is supported by eight towers, 250 m. high, of the American type, and the 1,000 kw. arc gives a maximum current of 600 amperes working with waves of 24 km. length. The projected stations on Long Island, near New York, and at Ste. Assise, near Paris, will surpass Lafayette. At Port Jefferson, Long Island, 12 antennæ, radiating from the power house, are each suspended on six towers, 410 ft. high, and carry spreaders 150 ft. long for the support of the 16 wires; the total area covered will be 10 square miles, and ten 200 kw. Alexanderson alternators are to supply the current. At Ste. Assise the double Marconi antennæ is supported on 16 towers of 250 m. height; two 500 kw. Latour alternators are projected. Next to Lafayette, Nauen near Berlin is still the most powerful station. The Federal Radio Company of San Francisco plans two huge stations, at San Francisco and Shanghai, a distance of 5,300 nautical miles, each with towers 1,000 ft. high. The British Imperial chain will cover the distances of 5,300 nautical miles to Egypt and Cape Town, and of 7,700 miles to Egypt, India, Singapore and Australia, in steps of about 2,000 miles, starting from Leafield, near

Oxford. That plan of using intermediate stations seems to promise the most reliable service, though it may not be able to deal with the largest volume of traffic.

Radiotelegraphy need not, and will not, replace ordinary telegraphy and cable service. But everybody will welcome its further development, for instance, for the purpose of connecting business centres with outlying mines and camps and in other ways promoting industrial progress.

THE INTERNATIONAL RAILWAY CONGRESS AT ROME.

THE series of International Railway Congresses dates from 1885, when the Belgian Government invited representatives of foreign Governments and of the principal railway systems of the world to come to Brussels to assist in the celebration of the fiftieth anniversary of Belgian railways and to discuss matters of common interest to railway men. The meeting was so successful that it was decided to form a permanent association, with headquarters at Brussels, and two years later a congress was held at Milan at which definite statutes were adopted, and the International Railway Association in its present form came into being. It was at first intended to hold the congress every year, but the attendance of head officials was found impossible at such frequent periods, and the interval gradually lengthened to two, three, and five years, which latter is now supposed to be the limit. Subsequent to the Milan meeting, the assembly met in Paris (1889), St. Petersburg (1892), London (1895), Paris (1900), Washington (1905), and Berne (1910). Germany did not participate in the congress till the Washington meeting, 1905, but the ninth meeting was arranged for Berlin in 1915. The war, however, intervened, and the activities of the association were suspended during the occupation of Belgium by the Central Powers.

At the termination of the war the association was brought to an end by order of the sequestrator, because it held credits belonging to the Central Powers. These funds were sequestered, while funds corresponding to the Russian share were deposited with a bank. The association was reformed on lines exactly similar to the old, but excluding the countries of the Central Powers and Russia. An article will be added, if approved at Rome, allowing any of these countries to re-enter the association on a favourable vote of a majority of three-fourths of the members.

The association as at present constituted is supported by the Belgian Government, and consists of about 260 different railway administrations representing over 227,000 miles of line. It may be here pointed out that in 1904, before Germany joined, the mileage represented was just over 208,800, so that although the highest mileage represented amounted to 274,650, the present position is still better than in that year, and quite representative of the world in general.

The Ninth Congress of the series was arranged to take place this year at Rome, and this congress, which was formally opened on the 18th inst., holds its final session to-day, so far as business meetings are concerned, but several more days will be occupied by the delegates in making excursions to places of interest in Italy. The fact that it is the first congress for twelve years, and the attractions of Rome as a meeting-place, have resulted in a very large attendance—the delegates, together with the ladies of the party numbering something like 800. The influx of so many visitors to Rome, especially at Easter time, has severely taxed the hotel accommodation of the city, but the local organising committee have done everything possible for the comfort of the visitors. The badge worn by the delegates acts as a free pass on the tramways in Rome, and to the museums of Rome, Naples and Genoa, while the Italian State Railways have provided every delegate with a two months' pass over the railways throughout the country.

The congress meetings are held in the Fine Arts Exhibition Building, the ground floor of which has been cleared and furnished for the purpose. The inaugural meeting, which took place in the Grand Hall, was honoured by the presence of His Majesty Victor Emanuel III, the King of Italy. The delegates were welcomed on behalf of the Government by Sig. Riccio, the Italian Minister of Public Works, who was supported on the platform by M. V. Tondelier, President of the Permanent Commission; M.M. Ernest Gerard and C. Colson, Vice-Presidents; and M. J. Verdeyen, Secretary-General. Sig. Carlo Crova, Director-General of the Italian State Railways, and other gentlemen, were also on the platform.

In his address of welcome, Sig. Riccio reviewed the progress made in Italian railway development since the congress was held in Milan in 1887. In that year there were altogether 6,720 miles of main line railway, and 280 miles of secondary track giving a proportion of 2·44 miles of track for 40 sq. miles of area. The peace treaty brought to Italy 650 miles of ordinary lines and 225 miles of narrow gauge lines, in the territory which was added to the kingdom. The Italian Government now operates 9,805 miles of ordinary lines, 412 miles of narrow gauge, and 135 miles of narrow gauge in the Italian Colonies. Private companies operate 1,225 miles of ordinary line and 1,470 miles of narrow gauge. There are under construction for the State Railways 437 miles of ordinary and 118 miles of narrow gauge, while 680 miles of ordinary or narrow gauge are being built by private companies. Furthermore, the State Railways have projected an additional 205 miles of ordinary and 500 miles of narrow gauge, and private companies propose to build an additional 135 miles of line. In connection with these extensions there was a vast programme of electrification which the delegates would have an opportunity of examining and discussing.

Sig. Riccio having formally declared the congress open, M. Tondelier, President of the Permanent Commission and Member of the Administrative Council of the Belgian State Railways, reviewed the history of the International Railway Association, and thanked the Italian Government for the welcome they had given to the congress. He referred to the loss the association had suffered by the death of M. Dubois, who had held the presidency for twenty years; M. Weissenbruch, who was secretary-general until his death last August, and other men who had devoted much energy to the welfare of the association.

On the motion of M. Tondelier, Sig. Riccio was appointed hon. president of the congress, and Sig. Crova, the director-general of the Italian State Railways as acting president. The latter, in his address to the meeting, pointed out that the Italian system was the most extensive of the State Railways of Europe, and briefly reviewed its development. In 1905 the Government took over the operation of the lines worked by the Mediterranean Adriatic and Sicilian companies, and by 1920 it had absorbed almost all the remaining railways operated by private enterprise, a total of about 2,175 miles. The co-ordination of all these lines presented considerable difficulties in the way of organisation, and a great expenditure of money to get them into a satisfactory condition. From July, 1905, to December, 1921, the expenditure on new lines amounted to 736,817,809 lire, while expenditure on permanent plant, rolling-stock and stores was 2,826,575 lire. During the year 1920–21 the expenditure on fuel reached the figure of 1,128,180,140 lire, maintenance of lines 79,131,234 lire and *personnel* 2,193,477,009 lire. The latter sum might cause surprise, but it was accounted for jointly by the effect of the war, the 8-hour day, and by increases of wages and bonuses granted to meet the cost of living. Among the lines under construction were the Florence-Bologna and Genoa-Arquila express routes, both crossing the Apennines, the first with a tunnel 11½ miles long and the other with a tunnel nearly 10 miles long. These would be arteries of the highest importance, being double tracked and designed with very easy gradients, easy curves, and practically without level crossings.

Locomotives had increased in number from 3,079 in 1905 to 5,780 in 1921, exclusive of about 500 which belonged to the recently-annexed provinces. There were now 244 electric locomotives in service and 52 motor carriers. Passenger coaches had increased from 7,008 to 11,389, postal vans from 1,752 to 4,696 and wagons from 52,324 to 157,374. Two technical problems had recently been satisfactorily solved, namely the use of liquid fuel on locomotives and the purification of boiler feed water. The adoption of liquid fuel had, however, to be abandoned on account of the prohibitive price of oil. As regards the purification of feed water, this was now definitely settled, and the State Railways had at present 28 purifiers at work, capable of treating more than 16,000 tons of water daily.

As regards electrification, Sig. Crova stated that in view of the experience gained by the late operating companies on the Milan-Sondrio-Jirano line with a 3,000-volt overhead system, and on the Milan-Varese line with a third rail system, the Government decided definitely to adopt the overhead system for all lines, even on the steepest gradients. They began with the two lines of the Giovi, with a gradient of 35 per cent., these lines having become insufficient to carry the traffic from the port of Genoa. The results of these and other electrically-operated lines were so good that further electrification was contemplated, and now that the end of the war permitted the work again to be proceeded with, it might be regarded as certain that in six or seven years time, about 3,125 miles of heavy traffic lines would be operated electrically. The power being, of course, obtained from waterfalls, a considerable saving in the cost of fuel would be made by the change.

(To be continued.)

NOTES.

PROPOSALS FOR COMBINED TURBINES AND DIESEL ENGINES IN WARSHIPS.

As time passes, evidence accumulates of the serious check which the war made in research and experimental work in various departments of industry, because the whole of the resources, physical and mental, were directed exclusively to the winning of the war and the necessary development of old, and evolution of new, munitions. The paper by Sir George G. Goodwin, the Engineer-in-Chief of the Fleet, to the institution at Glasgow, which we reproduce on page 835 of this issue, affords evidence of the cessation of experiments not only interesting in themselves but promising in their application. This is particularly so in reference to the combination of Diesel engines and turbines for the propulsion of various types of warships. For instance, in 1911 a scheme was evolved whereby two sets of two-cycle Diesel engines were to be fitted forward of the turbine engines and were to operate, through helical gearing, the turbine and propeller shafts, the idea being to use these oil engines exclusively for cruising purposes. Difficulties were, however, experienced during the manufacture, and the idea was ultimately abandoned. Later, even in ships of the battleship type, designs were prepared for fitting oil engines on two of the shafts and turbines on the remaining two shafts, also with the view of driving the ship at cruising speeds solely with the Diesel engines. But even in the case of the "Hood" the idea of oil engines for cruising speeds was entertained, although it will be remembered that the power in this case was the highest that had at that time been contemplated for a warship. In this instance the idea most favoured was to have a centre shaft, making five propellers in all, leaving the two wing port propellers on the port and the two wing starboard propellers to be run at the highest speeds, as usual, by turbine installations. The centre shaft was to have a Diesel engine, the power of this engine being ultimately increased to 4,000 h.p. The final proposal was to fit two sets of eight-cylinder engines, totalling 9,000 h.p., on the wing shafts and sets of turbines on the three inner shafts, but these proposals were ultimately abandoned. It is well, however, to have them on record in Sir George Goodwin's paper, which, further, is interesting by reason of the valuable experimental work now in progress with various types of oil engines, including the two-cycle double-acting engine, now being tested at the Government experimental station.

FISHERIES AND WASHINGS FROM TARRED ROADS.

In 1919 the Ministries of Transport and of Agriculture and Fisheries appointed a committee to inquire into the risks of damage to fisheries by rain-washings from tarred roads. The problem

was by no means a simple one, and an experimental station was established at Alresford, in Hampshire. This station was completed by February, 1921, and by August 20 last, the carriage way of the main road adjoining the station was tarred, an adequate study having previously been made of the effect on trout of the rain-washings from the road in the ordinary condition. The Interim Report issued a few days ago by the committee, through its secretary, Mr. I. Powell, of the Ministry of Transport, only offers tentative suggestions, as the work is being continued; but the report certainly deserves the careful consideration of highway authorities. There is no doubt that the rain-washings from tarred roads will kill fish and will damage watercress and probably other vegetable crops. At the same time it seems likely that the damage can be much reduced by expedients on which the public would be entitled to insist. The portion of the road from which the rain washings are diverted into the experimental fishponds at Alresford has a length of 550 yards and an area of 3,300 sq. yards; 1 in. of rain falling upon that road section would correspond to 15,420 gallons of water. In order to collect all the drainage from that portion, which slopes both ways down to gullies, and to prevent water from the grass edges from flowing on to the road, firwood edgings have been provided on both sides of the carriage-way. A pipe from the gullies carries the water to two ponds, each 9 ft. by 4 ft. by 2 ft. deep, containing 700 gallons of water, while water from the Itchen River flows continuously through the ponds at the rate of 1,200 gallons per hour. There are also a control pond and a storage tank for the road washings, and these waters may enter thb pond directly or after having passed through turf filters. The rain of August 23, three days after completion of the tarring with a straight-run coal tar, killed the trout and other fish in the pond within 15 minutes, that is, before the maximum concentration of the washings had been attained, whilst the ammonia and phenols of vegetable origin from the washings of the untarred road had no injurious effect. From subsequent observations it is concluded that these rain washings from freshly-tarred roads would be injurious unless the washings were diluted with 10 times their volume of water, but that subsequent washings would be much less injurious. A period of strong toxic effect would again follow later, however, when the road begins to disintegrate. For the treatment of roads directly draining into fishing waters the committee therefore recommend that highway authorities should give preference to asphaltic bitumen free from tar products; washings from such bitumen do not appear to have any specific deleterious effect on fish or other stream life.

The Acoustic Propagation of Explosion Reports.

It has long been known that explosion-waves travel faster than sounds of moderate intensity, and various determinations of this rate of propagation were made during the war. The systematic and elaborate experiments, which E. von Angerer and R. Ladenburg describe in the *Annalen der Physik*, vol. lxvi, pages 293 to 323, were also conducted during the war, in the years 1916 to 1918, and in conjunction with the military authorities; but they had little to do with the operations at the front. Two grounds were chosen, one in the low planes of the north-west, the other in the Bavarian high lands at altitudes ranging from 1,000 m. up to 1,700 m. On these grounds triangles A B C, approximately rectangular and isosceles, were laid out; the lengths of the sides were either 6 km. or 10 km.; the right angle was at B, and the direction A B was south-north, and B C east-west. Charges of ammonium nitrate (generally 3 kg.) were exploded at the points A, B, C, and the advance of the explosion wave (in either direction) was watched with the aid of microphones mounted along the sides. The explosion itself broke a wire circuit; time intervals of $\frac{1}{50}$ second were marked on a moving photographic film, these divisions being about a millimetre apart. Temperature, wind intensity and direction, moisture, &c., were determined at different levels, partly with the aid of kites and balloons and also of smoke-puffs sent up from pistols or small mortars. As a rule three explosions at A, B, C, would follow one another within 3 minutes, during which the atmospheric conditions would change little. More than 500 series of measurements were taken on 80 days. It was observed that the velocity of the intense sound was, at considerable distance from the source, 330·8 m. per second (reduced to normal pressure and 0 deg. C.). That normal velocity, which is slightly lower than the accepted theoretical value of the propagation of sound, 331·5 m. per second, would be reached within a distance of 100 m. from the source, with explosive charges of 3 kg., whilst with heavy gun charges of 200 kg. it was not reached within 200 m. from the source, the observed velocity being still above the normal value. With the 3 kg. charges the velocity close to the source, within 3 m. from it, was 1,150 m. per second; within 6 m. it had come down to 470 m., and within 12 m. to 380 m. per second; thus the acoustic wave proper lagged behind the explosive wave. To far distances the sound would apparently travel, not in straight lines, but in arcs, the rise of the arc being the higher the greater the distance, so that the observer fancied that the report came obliquely from above. The curvature was due to the well-recognised fact that the wind is generally stronger at moderate height than on the ground. A wind in the sound direction would depress the acoustic wave, a contrary wind would tilt it up, the secondary wave preceding the primary wave by up to 0·3 second, or lagging behind it with opposing wind. Contrary wind weakened the sound intensity very much in the planes. Temperature inversions (when the air temperature is higher some way up than near the ground), and also mists gave rise to strong echoes; but the mist did not delay the sound propagation. The direction of the source was determined by the aid of Zenneck method (microphones mounted at the corners of a triangle); in the plane this method proved quite reliable, within half a degree of arc mostly, but in the hilly district errors of several degrees occurred. The wave form as registered on the films underwent striking changes with increasing distance from the source.

Resources of Portuguese East Africa.—The last report by H.M. Consul-General at Lourenço Marques, recently issued by the Department of Overseas Trade, states that Portuguese East Africa has immense possibilities in agriculture of the most varied kinds, and perhaps also in mining. In regard to mining, the activities do not appear to have passed the prospecting stage. The existence of abundant supplies of excellent hard woods in the southern part of the country has led to the growth of a furniture-making industry at Lourenço Marques which has great prospects of success; large orders for furniture are being executed, and further orders are expected; this, in addition to large contracts for sleepers for the South African Railways. Lourenço Marques has proved most particularly useful during the last few years as a port of shipment of coal from the Transvaal coalfields.

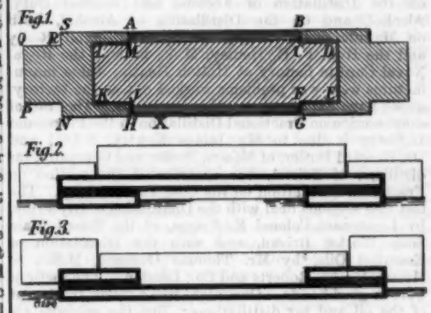
The Soviet and Swedish Industry.—Considerable comment was made when the Soviet Government secured a very pronounced influence in the old and well-known firm of Nydqvist and Holm, Trollhättan, manufacturers of locomotives, hydraulic turbines, &c., and the concern felt in the Swedish iron and engineering industry has increased lately on account of the extension of the Soviet's sphere of interest. Nydqvist and Holm also own two fairly large undertakings in Eskilstuna, and similar concerns at Karlstad and Falun are more or less intimately connected with the Trollhättan firm. Recently the list has been further extended by the acquisition of the Forsbacka iron works and the Lidköping Engineering Company. Special exception is taken to the fact that the former is being materially extended, it being urged that the Russians might instead have placed those orders which were beyond the capacity of the works they control with other Swedish firms.

Roller Bearing Mine Tub Wheel.—A new design of mine tub wheel fitted with roller bearings has just been brought out by Messrs. Hyatt, Limited, 56, Victoria-street, S.W. 1. This wheel embodies the firm's well-known spiral flexible rollers. In this design the wheel hub is solid on the outside without any detachable cap to become loose or get damaged. The rollers are seated directly on the journal, and are retained lengthwise between a floating washer held in position on the journal end, and, on the inside end, by a washer and gland nut, the latter screwing into the inner end of the hub. A good length of bearing is provided for the hollow flexible rollers. The rollers alternate with right and left hand spirals, so that the constant circulation and distribution of the lubricant is assured. It will be evident that a well-designed totally-enclosed bearing of this type will effect very considerable reduction in lubrication costs, while the reduction in the tractive effort required as compared with the plain journal will have considerable advantages in operating.

THE KLITZING SELF-DOCKING DOCKS.

Though experience has proved that the steel pontoons of docks are, as a rule, little liable to be corroded under water, examination and repairs become necessary in the course of years. For this purpose the pontoon has itself to be docked, unless the dock is of the self-docking type. In these latter docks provision is made for raising the bottom of the pontoon above the water level. The peculiar way in which von Klitzing attains this is indicated in our diagrams, Figs. 1 to 3. Two docks of his design, each of a floating capacity of 7,000 tons, built by the Dockbauwerft Flender, of Siems, near Lübeck, have recently been supplied to Scandinavia, and one of these, we see from the *Zeitschrift des Vereines Deutscher Ingenieure*, of February 11, was successfully tested by the Nylands Wharf, of Kristiana, before acceptance.

The point that our diagrams are to explain is that the dock consists of three separate pontoons, a central pontoon and two end pontoons, and that either the middle pontoon or the end ones can be raised by the buoyancy of the other part or parts. Fig. 1 shows the three parts in plan. The middle main pontoon, A B C D E F G H J K L M A, is shaded in one direction, the two end pontoons are shaded in a different direction. The horizontal shading, partly bordered



by the dotted lines, indicates in both cases the pontoon walls, which rise above the flat floors. As shown in Fig. 1, the three pontoons are in the ordinary working position. When a docking operation is to be performed on the middle pontoon, both the end pontoons are reversed, turned about their vertical axis through 180 deg., while floating. If we confine ourselves for the present to one end pontoon, *e.g.*, the one on the left-hand side, A M L K J H N O P Q R S A, the points P and Q will, after reversal of the end pontoon, touch the points L and K of the middle pontoon; the two floors will be on the same level and the walls in alignment. The end pontoon is now lowered by admitting water into the bottom chambers, and the floor P Q L K is pushed under the left side of the floor of the middle pontoon L M J K. The same operation is performed on the right-hand side. The buoyancy of the two end pontoons will then, after pumping the water out, be able to raise the middle pontoon as indicated in Fig. 2. The main pontoon can thus be inspected and repaired. When one of the end pontoons is to be repaired, they have both to be lifted, and this is accomplished in a similar way, except that the middle pontoon is now lowered so that the floors of the end pontoons can be pushed over the floor of the central pontoon; Fig. 3 illustrates this position. The walls always remain in alignment after completing the turning operation.

It is stated that the separation of the pontoons into three separate bodies does not cause any particular difficulties as regards the arrangement of the hydraulic pipe system. Nor are special under-water couplings said to be required when the docks are being bodily towed across the sea; the necessary connections are made in the longitudinal girders of the bottom pontoons and in the lateral walls. The recessing of the end pontoons into the central pontoon increases the stability of the whole dock.

Hemp Hurds for Paper-Making.—The Forest Products Laboratories of Canada, Montreal, have carried out investigations as to the value of the waste stalks of hemp from which the fibre has been removed, as a paper-making material. These are called "hemp hurds." Considerable quantities of the hurds, at present a mere waste product, are available in Canada. Some attention has been given to this subject in the United States where experiments have been made in which the soda process was used. The work at the laboratories, however, has been directed towards the application of the sulphite process, widely used in Canadian pulp mills for the manufacture of chemical wood pulp. The results obtained indicate that while the material lends itself to sulphite cooking the resulting pulp has an extremely short fibre and is somewhat hard to bleach. The yield, however, is large, and the pulp might advantageously be used as a filler with pulps of longer fibre.

NOTES ON NEW BOOKS.

When Professor Sydney Young, F.R.S., entered in the 'eighties, upon his well-known thermodynamic researches concerning the equation of state and vapour pressures, he was engaged in the preparation, largely by distillation, of various chemicals in the purest possible form. In the course of eighteen years devoted to this work he collected a large amount of valuable experience as to efficient methods and apparatus for distillation, and his treatise on "Fractional Distillation," published in 1903, at once found ready appreciation. At the beginning of the war that volume was out of print, and Professor Young had meanwhile gone from Bristol to Dublin. The publishers had to decide whether a revised edition should be issued, or the scope of the work be extended so as to include distillation on technical scales. The latter plan was adopted. In the new volume on "*Distillation Principles and Processes*" [London: Macmillan and Co., Limited, price 40*s.* net], Professor Young is associated as author with several other experts. The first section, which occupies 229 pages out of a total of 509 pages, is practically a thorough revision, not a reprint brought up to date, of the original "Fractional Distillation," again by Professor Young, assisted by Professors F. E. Francis and W. E. Adeney. The next two sections, on the Distillation of Acetone and Normal Butyl Alcohol, and on the Distillation of Alcohol, both on Manufacturing Scales, are by Dr. Joseph Reilly and the Hon. F. R. Henley, M.A., both of the Royal Naval Cordite factory at Holton Heath; these manufactures were war problems worked out at the factory, as we have explained on other occasions. The rather short section on Fractional Distillation in the Petroleum Industry is due to Mr. James Kewley, F.I.C., and Dr. Howard Butler, of Messrs. Butler and Company, tar distillers, of Bristol, has contributed the section on Fractional Distillation on the Coal Tar Industry. The last two sections deal with the Distillation of Glycerine, by Lieutenant-Colonel E. Briggs, of the Broad Plain Soap Works, Bristol, and with the Distillation of Essential Oils, by Mr. Thomas Durrans, M.Sc., of Messrs. Boake, Roberts and Co., London. The sections were in good hands. One might like a fuller treatment of the oil and tar distillations. But the subjects are further treated, on more general lines, in the first excellent section, and each would require a large volume of its own.

The limitation of the mathematical training for the engineer is a controversial question. We agree with the view expressed by Professor Heinz Egerer, in his "Ingenieur-Mathematik," that the mathematical training of an engineer should suffice to make and leave him capable of thinking and feeling mathematically, and of resuming and extending, if necessary, his mathematical knowledge at a later period, and of grasping the mathematical significance of a technical problem. The training should neither be strictly theoretical, nor should it be attached to definite problems from the outset. The conceptions of force, resultant work, moment, and of vector diagrams should fully be understood before an attempt is made to work out real problems. That would not debar the teacher from explaining his meaning by simple examples, nor would it saddle him with unnecessary mathematical ballast. From these points of view the second volume of Dr. Ing. Egerer's "*Ingenieur-Mathematik*" [Berlin: Julius Springer; price 528 marks] appears to be a commendable book. It deals in its main sections with differential and integral calculus, including hyperbolic functions, equations and series, curves, theory of surfaces and of three-dimensional curves and maxima and minima. A third volume is to follow. Dr. Egerer writes from München; he was formerly professor at the Technical High School of Trondhjem, Norway. At first glance the mathematical expositions seem to take up almost undue space in the 728 pages of the volume which is illustrated by 477 diagrams; but the thousand worked-out examples form a very essential part of the book. The weak point, as frequently in German publications of this type, is the poor index. The student has to make the volume his particular guide to learn how to benefit from it.

For the demand which exists for a text-book dealing in a comprehensive manner with the metallurgy of the more usual metals and which does not give the elaborate details generally expected in treatises on particular subjects, we can recommend "*The Metallurgy of the Common Metals*," by L. S. Austin (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited; price 42*s.* net). In its 600 odd pages it describes the latest practice in general metallurgy and in the metallurgy of gold, silver, copper, lead, zinc, iron and steel, in a fairly complete way, while stressing all the time the descriptive and the practical sides of the business. The author's knowledge of his subject is shown to best advantage, however, in the non-ferrous sections, and we believe that the part dealing with iron and steel could well have been omitted without detracting from the value of the book. This section is too sketchy and short to be of real advantage to the student since he has to accept statements without being given the reason why, and knowledge from such a source becomes purely memory knowledge which is not permanent. There is a good section dealing with plant and equipment and their costs which is not usually mentioned in a book of this kind. It ought to be very useful indeed to the student wishing to get an insight into the broader aspects of his business which can only be acquired by practical experience. This book has already exhausted four editions, and we believe that this fifth edition will maintain the interest and value of the previous impressions.

Most of the important industries have their handbooks, giving a description of the leading technical features of the various types of products and indicating periodically the progress made. The "*Marine Oil Engine Handbook*" (Temple Press, London; price 3*s.* 6*d.* net), the sixth edition of which has just been issued, serves only partially for the growing business of supplying internal-combustion machinery to vessels. The title of this book is somewhat of a misnomer. By far the greater proportion of its 174 pages of letterpress is confined to the type of marine motor, most popular for small vessels, of the petrol-paraffin type, which is hardly the chief form of oil engine However, it is such engines that find their way into the hands of amateurs, or those who have no technical training and experience, so that this type of book is of value in this field. The explanations of the systems on which various types of engines work, such as the four-stroke cycle, the two-stroke cycle and hot bulb injection are carefully and clearly described. The subjects of vaporisation of fuel, electrical ignition, somewhat difficult of explanation to the beginner, are fully dealt with. Chapters, well illustrated, describe individually all the best-known makes of semi-Diesel, petrol-paraffin, and outboard motors, and it is subject for remark that the numbers of types of semi-Diesel and outboard motors seem to be on the increase. The semi-Diesel engine is gaining ground because of its robustness, slow speed of revolution and the utilisation of lower grades of fuel than paraffin, and the outboard motor on account of its handiness and the ease with which it can be fitted to ordinary dingies, &c. Mention is made of the Diesel engine in a couple of pages, but it can hardly be said as yet to have entered the field generally covered by this useful little work. It might be suggested for future editions that tables indicating the numbers of types and powers of engines installed, in use, and building would considerably enhance the value.

In 1891, Messrs. T. Cooke and Sons, of Buckingham Works, York, the well-known makers of astronomical telescopes, prepared a small handbook entitled "*On the Adjustment and Testing of Telescopic Objectives*," which they issued for the benefit of the users of their instruments. This book contained much practical information which is not to be found in optical text-books, and it was so favourably received, that in 1896 a second and enlarged edition was published, this embodying the information contained in the first edition with the addition of a chapter dealing with the triple photo-visual objective which was brought out in 1894 as the result of long-continued experiments made by Mr. Denis Taylor, the optical manager of the firm. Two papers contributed by Mr. Denis Taylor to the Royal Astronomical Society, namely, one on "The Secondary Colour Aberrations of the Refractory Telescope in Relation to Vision" and the other entitled "A Description of a Perfectly Achromatic Refractor," were also reprinted in this volume. Now Messrs. Cooke and Sons have brought out a third and further enlarged edition of the book which includes in its contents a paper by Mr. Denis Taylor entitled "An Experiment with a 12½-in. Refractor," which is reprinted by permission from the memoirs of the Royal Astronomical Society. The price of this new edition is 12*s.* 6*d.* (or 12*s.* 10*s.* post free). The book is by far the best guide to the testing and adjustment of telescopic objectives which has come under our notice, and it includes good practical advice as to the care of objectives and other information which will render it of great value not only to users of astronomical telescopes, but to all who are interested in making themselves acquainted with the conditions which a good telescope should fulfil.

A general descriptive account of the appliances, tools and methods which characterise a modern engineering workshop forms a very useful volume for a student or apprentice, and in "*Modern Workshop Practice*," by Ernest Pull (Crosby, Lockwood and Son, London; price 16*s.* net), we have a work of this nature which has now reached its sixth edition. Except for a short chapter dealing with the smithy, the whole of the 650 pages of the book is practically confined to machine-shop practice, the foundry and pattern-shop being disregarded entirely. The illustrations are copious, being almost numerically equal to the pages, and though many of them awaken reminiscences of manufacturers' catalogues, they are none the less useful to the youth who is as yet unfamiliar with the machines and appliances themselves. The scope of the book is very wide and the treatment, being elementary and general, is of necessity somewhat sketchy. Nevertheless it will serve as a readable introduction to the practical work of the machine shop. Being unpretentious it lays itself open to little criticism, but occasionally one finds points which will bear comment. In dealing with flanged couplings, for example, the author quite rightly states that the faces of the flanges should be turned after the latter have been keyed on, but neither the letterpress nor the illustration conveys the even more important fact that the flanges should be made to register with each other. Points like this, however, any observant apprentice will note for himself, and the book is one which should form a useful and appreciated possession of any apprentice, as it will familiarise him with the tools and appliances amongst which he finds himself.

A volume, the contents of which are made up of articles published by various authors in some periodical, does not offer much promise of systematic treatment. Yet "*Power's Practical Refrigeration*," compiled by the editorial staff of *Power* [the McGraw-Hill Publishing Company, Limited; *Power*, 6 and 8, Bouverie-street, E.C. 4; price 10*s.* net], may be accepted as a useful practical book by American authors. The book has its limits. Apart from a short section on carbon dioxide machines and a few notes on their testing, the volume is confined to ammonia machines, and that should have been mentioned. Perhaps the original scope was wider, for the volume opens: "Section I: Refrigeration made Simple"; but there is no section II to follow, and the statement "made simple" well characterises the contents. Attention is very properly drawn to the importance of controlling the working of compressors by taking numerous indicator diagrams. "As logarithms are not well understood by most engineers," the author explains how to construct adiabatic and isothermal curves without the use of logarithms. Metric measures and the c.g.s. system are not used at all; it is all in British or American measures, and the British thermal units are written B.t.u. The third chapter on the "Use and Care of Compressors" describes different types of machines, and especially their valves, rather than giving general notes. Those we find in Chapter VII, "Operation of the Compression System," "in which appears a Number of Practical Articles of such Interest that the Author is credited with the material"; so far the author had not been named. In this section, Mr. E. W. Miller deals with the "Location of Ammonia Leaks" and their detection, telling us that "sulphur can be had at any drug or chemical store and costs but little," and writes further under the heading: "On the Job with the Refrigerating Troubleman," Mr. C. Bromley reviews some "Ammonia Explosions," Mr. Thomas G. Thurston discusses other "Symptoms of Troubles," &c. all useful, mostly, but perhaps a little too much in the "made simple" style.

Whilst progress in the use of pulverised coal has so far been comparatively small in this country, American engineers have taken it up seriously and energetically. When therefore the Fuel Research Board was approached early in 1918 by Mr. Leonard C. Harvey, who intended to visit the United States in order to investigate the whole position, the Fuel Board assisted him, and a first report on the "*Pulverised Coal Systems in America*," drawn up by Mr. Harvey, was published in 1919. Later on Mr. Harvey sent a questionnaire to a large number of users of pulverised coal in America, and last year he paid a further visit to America in the same interests. The Fuel Research Board has therefore authorised the publication of a revised edition of Mr. Harvey's report, a small quarto pamphlet of 117 pages, which can be obtained from H.M. Stationery Office at the price of 5*s.* net. Sir George Beilby has written a foreword. The book deals with the class of suitable fuel; the cost of installation; mill house practice; transportation of coaldust to burners; feeders, mixers and burners; and applications, among which the power plant of the Milwaukee Electric Railway and Light Company, which Mr. John Anderson described in 1920, claims chief interest. The long literature list in the volume shows that much more has been written on the subject than actually done. As to the drawbacks of pulverised coal, Mr. Harvey acknowledges the difficulties of storage, transport and conveyance in the works, the troubles due to the re-absorption of moisture, and the dangers of

spontaneous combustion and explosions. The dangers are real, but not greater than with gas or oil. But the preparation, costs, and the heavy capital expenditure on the plant are serious drawbacks, standing in the way of rapid advance. Mr. Harvey's report is instructive, and would call for longer notice if we had not repeatedly dealt with the subject.

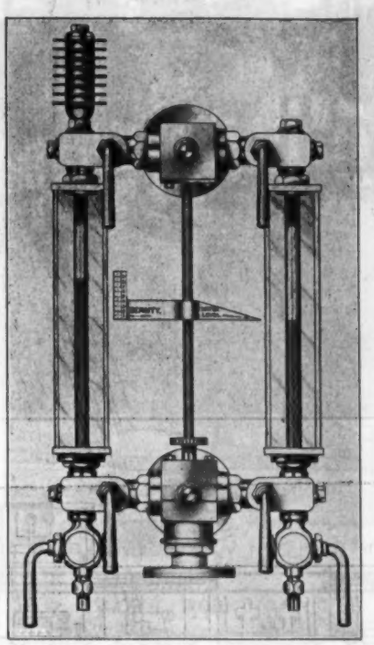
The excavations, embankments, &c., involved in the construction of railways which pass through diversified country constitute engineering works of considerable importance, and though earthworks of this kind can only be carried out efficiently by practical and experienced men, even they will read with interest a book dealing with the underlying principles which govern such undertakings. Such a book entitled "*Earthwork in Railway Engineering*" has recently been published by Messrs. Constable and Co., Limited, at the price of 15s. net, as one of the Glasgow Textbooks of Civil Engineering under the editorship of Mr. G. Moncur. The author is Mr. John W. F. Gardner, M.Inst.C.E., who writes as the outcome of practical experience gained largely when acting as resident engineer under Mr. Donald A. Matheson, formerly engineer-in-chief and now general manager of the Caledonian Railway. A book of this kind is bound to be general in its nature, as though the principles of earthwork construction are, when reduced to their simplest terms, identical with the principle of all engineering work, namely, to get the job done effectively at the lowest cost, the application of the principles will vary in each particular piece of work to be done. Nevertheless, examples of how work has been done, and advice as to how best to deal with given conditions are always useful, and the book in question will be found interesting and suggestive by those who are responsible for the actual carrying out of railway earthworks.

THE "KEK" DENSIMETER FOR STEAM BOILERS.

WHEN the feed-water of a boiler contains soluble salts, as all hard or artifically softened water does, the density of the water in the boiler continually rises owing to the concentration of these salts by evaporation. In a modern water-tube boiler, the hourly evaporation may be equal to the entire water contents of the boiler. In such a case, supposing the feed-water contained only four grains of soluble salts per gallon, and the boiler evaporated 20,000 lb. of water per hour, the amount of salts in solution in the boiler water would rise to 2,000 grains per gallon after 500 hours' working, assuming no water was lost by leakage or by blowing down. This would be twice the density which is considered allowable in water-tube boilers, and it is therefore evident that periodical blowing down would be necessary to keep the density within safe limits. In ordinary practice it is not easy to determine how often and how much blowing-down is really necessary, and consequently firemen usually work to some rough-and-ready rule, as blowing down 2 in. out of the gauge glass every shift, or every day. This is not very satisfactory, as it is liable to result either in an unnecessary waste of water and heat, or in insufficient reduction of the density of the boiler water.

To enable the density of the water to be readily determined at any time, without the use of salinometers or hydrometers, and thus to provide the fireman with a means of regulating his blowing-down in exact accordance with requirements, the Chemical Engineering Company, Limited, of 49, Deansgate, Manchester, have introduced a simple apparatus called the "Kek Densimeter," of which they are the patentees and sole makers. This apparatus is shown in the figure annexed. It works on the principle of balancing, as in the legs of a U-tube, a column of the boiler water against a corresponding column of pure distilled water. The latter, being less dense, will, of course, stand at a higher level, the difference of the levels being a measure of the density of the boiler water. In the actual apparatus the legs of the U-tube are two pipes, the lower ends of which are open and in communication with the water in the boiler. The upper ends terminate in the gauge glasses seen in the illustration. The steam space of the boiler is in communication with the upper ends of the glasses. The gauge glass shown on the right-hand side of the illustration behaves exactly as an ordinary gauge glass and shows the true level of the water in the boiler. The left-hand glass, however, and the pipe with which it is connected always contain pure distilled water, which is continually replenished by the condensation of steam in the ribbed chamber seen above the glass in question. It is obvious that the water level in the two glasses will be different according to the greater or less density of the column of boiler water against which the column of distilled water is in equilibrium, and the density of the boiler water may thus be read directly from a suitable scale. Before taking an exact reading, the fireman blows out the water from the right-hand glass. On closing the valve the water is immediately replaced by a fresh sample of the water in the boiler, so that there is no doubt that the conditions at the time are truly represented.

The scale of density usually employed in connection with feed-water is based on the density of sea water. A column of sea water 32 in. high will balance a column of pure water 1 in. higher, and from this fact the density of sea water is called $\frac{1}{32}$. The column of pure water in the densimeter is usually made 128 in. long, although it is sometimes made 160 in. long when the height of the boiler permits. In the former case, supposing the boiler water were at sea water density, the difference in levels in the two gauge glasses would



be 4 in. The maximum safe density of boiler water being only half that of sea water, a red line is marked on the scale at a height of 2 in. to indicate the safe limit. Each inch of the scale is divided into four parts, so that each division represents one-sixteenth of the density of sea water. When the longer pipes are used, each division then represents one-twentieth of sea water density. The densimeter is fixed to the boiler in the same way as an ordinary water gauge, which it much resembles in appearance, and one side of it, as already pointed out, performs the function of a water gauge. We understand that the device is approved by the principal boiler insurance companies, and it undoubtedly facilitates the economical and safe operation of boilers.

STRAITS TIN.—For many years, British Malaya contributed more than one-half of the world's tin supply, and to-day the Federated Malay States still hold first place as the largest individual producers, though the export has fallen from 50,837 tons in 1908 to 34,446 tons in 1921. The tin-ore exported from the hinterland is smelted in Penang and Singapore, and Straits tin takes the highest rank in the metal markets. Tin exports from the Straits Settlements ports are shown in the following:—

	Tons.	Value. £
1913	65,700	13,171,582
1914	66,233	9,988,605
1915	68,782	10,686,813
1916	65,231	11,392,201
1917	64,031	11,782,071
1918	55,045	10,755,379
1919	59,342	15,017,368
1920	49,307	14,905,850

The following values of tin exports to the four main importing countries are also interesting:—

	1913. £	1918. £	1919. £	1920. £
United Kingdom... ...	7,039,338	3,199,592	4,823,872	4,006,851
United States...	3,565,588	10,493,452	6,991,629	8,527,794
France... ...	519,129	1,773,173	700,342	843,663
British India and Burma...	372,772	428,664	596,802	649,635

In considering these figures, allowance must be made for the lack of shipping facilities to Europe and for other war influences.

PATENT OFFICE METHODS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the above connection inventors owe a debt of gratitude to Mr. John G. Hudson, M.Inst.C.E., for his letter to ENGINEERING, and also to yourself for printing same in the current number of your valuable paper.

I rather think that Mr. Hudson's experience is by no means exceptional, and that he has been better treated than a large number of inventors. My own experience with a recent patent, I think, was worse than his. I left my complete specification in good and reasonable time, and after some months it was returned to me for amendment, which was duly carried out and again taken to the Patent Office. As the time was now getting short for completion I personally visited the Patent Office to learn what progress the patent had made; I was informed that a letter was on its way out to me. However, I was allowed to see the examiner, and discussed the amendment required. I re-drew my specification and again placed it or, rather, lodged it at the Patent Office. This process, of course, took a few days, but even then I did not receive the hereinbefore referred letter until later.

On February 4 (Saturday), at 4 p.m., I received a letter from the Patent Office returning again my specification, demanding modification and making an appointment for hearing at 11.45 a.m. on February 6 (Monday); such brief notice made it quite impossible for me to either attend the hearing or to get my specification modified, with the consequence that several specific references were inserted (many of which were not even of the same subject-matter) and I duly received notice in a letter dated February 7 (Tuesday) to the above effect, and inquiring whether I proposed to go further with the application and, if so, I should have to send in Patents Form 8 (a polite way of telling me I had to pay 2*l.* for their dilatory habits). The letter was signed by A. R. Wright, Acting for Comptroller-General.

Now I think one must, in justice and fairness, say that no one can complain of the way the technical staff at the Patent Office treat the public; I am sure nothing could be more pleasant than the courteous and patient way the examiners conduct their onerous and perhaps monotonous duties. The trouble lies with the executive chiefs who appear to treat the public with the bureaucratic highhandedness—no, I won't use Mr. Hudson's words, I will say contempt, that much more expresses the usual attitude of the civil servant to the British public; how long the latter are prepared to let it continue remains to be seen, but in the meantime it is doing great injury to the State, and such attitude on the part of the civil servant will ultimately cause a rupture between the people and the Government to the great disadvantage of both.

Now it appears to me that these dilatory habits and autocratic demeanour of the executive staff at the Patent Office should be dealt with by, say, a Royal Commission, but as this is one of the proverbial slow processes of Parliamentary Procedure it would perhaps be better to consider some other method. It might be suggested, perhaps, that several of the prominent engineering societies and institutes might with advantage combine together to bring pressure on the right authority to amend the present conditions to the great advantage to all concerned, not even excepting the people concerned at the Patent Office, who would then take a rather modified perspective of their relationship and obligations to the public.

It is a most extraordinary thing. No country has benefited so much from the inventor as our own, and yet he is treated far less liberally here than abroad. Notwithstanding the progress of time our Patent Office still holds on to the old primitive and obsolete methods. As an example the subject has here to pay for a patent whereas a citizen in the United States of America demands a patent of his Government; the one is mediæval, the other modern, where the Government is the servant of the public and not the master.

Yours faithfully,
W. STEEL PARSONS.

Radford Bridge, Enstone, Oxfordshire.

CALENDAR.—We have received from the Birmingham Small Arms Company, Limited, Birmingham, a calendar from the present month to March, 1923, illustrating a number of specialities of Messrs. Burton, Griffiths and Co., Limited, 70, Vauxhall Bridge-road, S.W. 1.

SHIPBUILDING IN DANISH DOCKYARDS.—In answer to the criticism of the high cost of shipbuilding work in the Royal Dockyard in Copenhagen which has appeared in the Danish press, the Naval Ministry has considered it expedient to make a statement on the matter. About two years ago the dockyard commenced the building of two steam ferries for the State Railways and a cable steamer for the Great Northern Telegraph Company at the request of the bodies concerned, no private yard at that time being able to accept the orders. The work was undertaken by the dockyard on a time and materials basis, and the cost of one of the ferries specially mentioned came to five times the pre-war contract price for construction in a private yard. This, it is stated, is the natural consequence of the rise in prices of materials and labour, and at the instance of the Naval Ministry a commission has been appointed to investigate the figures for the other ferry. The report of this commission will be published in due course. Since the beginning of the war, it is pointed out, the normal staff of the dockyard has been fully employed on work for the Navy, and it is consequently not, as has been insinuated, for the purpose of keeping the staff employed that the dockyard has undertaken to build mercantile vessels.

TOTALLY ENCLOSED SWITCH GEAR FOR STEEL WORKS.

CONSTRUCTED BY MR. GEORGE ELLISON, ENGINEER, BIRMINGHAM.

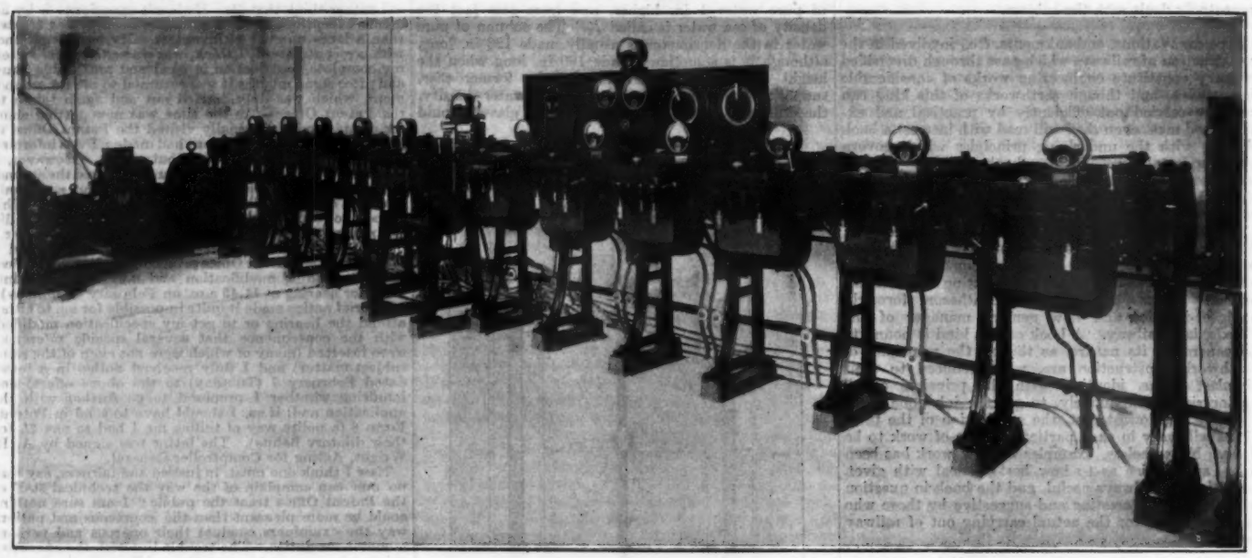
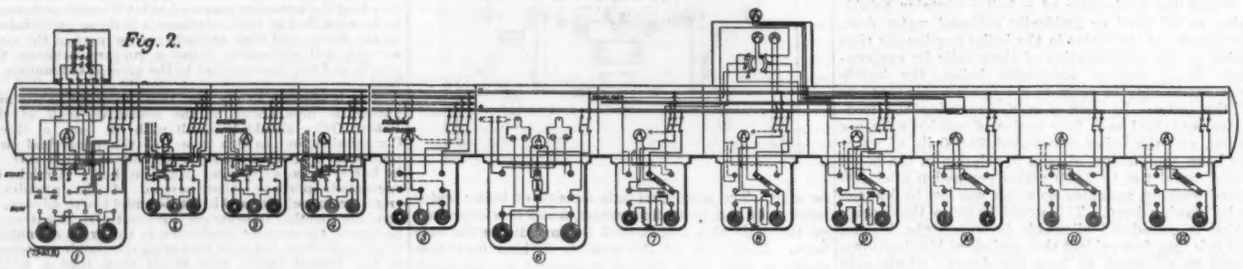


FIG. 1.

Fig. 2.



THE totally-enclosed unit type switch gear, manufactured by Mr. George Ellison, of Perry Barr, Birmingham, was described some years ago in our columns, and its general characteristics are now so well known that a brief reference to them is all that is necessary. A complete switchboard of the Ellison type is built up of separate panels, each of which is a self-contained unit, consisting of an oil-immersed circuit-breaker bolted to a steel chamber which encloses the isolating switches and bus-bars, and carries the necessary instruments, interlocking devices and cable fittings. These unit panels are supported on cast-iron stands, and are bolted together to form a compact, totally-enclosed, safe and weatherproof switchboard, which can be operated by the roughest labour. From the engineering point of view, the switchboards are interesting on account of the very high degree of standardisation and interchangeability which distinguishes them, a feature which not only facilitates manufacture, but makes extensions easy and promotes uniformity of appearance.

A recent example of an Ellison switchboard installed in an iron and steel works for the control of both alternating and direct-current circuits is illustrated in Fig. 1, above, the diagram of connections being given in Fig. 2. The board contains 12 panels, its overall length being 27 ft. 2 in. The first four panels control 400-volt two-phase circuits fed from an incoming feeder connected direct to the bus-bars. The first panel of the group contains an auto-transformer starter for the motor of an electric welding plant, the next starts an air compressor, and the others control motors of 50 h.p. and 70 h.p., respectively. The fifth panel controls a two-phase motor fed from a separate incoming supply at 200 volts. The remaining seven panels control direct-current circuits at 220 volts, three being generator panels, three feeder panels, and the other, situated next to the alternating-current part of the board being used for switching on an alternative stand-by direct-current supply.

Reverting to the standardisation which Mr. Ellison has adopted in his designs, we may mention that the switch gear units are made in three sizes only, namely, 20 in., 26 in. and 30 in. long. The bus-bar sizes are standardised to give capacities of 220 amperes, 440 amperes, 880 amperes and 1,320 amperes respectively, and the rotating switches of course correspond. Circuit breakers are built in three main sizes, each comprising double, triple and four-pole patterns. The mechanism of each breaker is contained in a cast-iron casing and oil tank, the joint between the cover and the tank being made by a grummet so arranged that the apparatus is completely dust and weatherproof, and the outside of the switch may be played upon by a hose pipe without risk of injury when the cable entrances are properly closed. Fittings and instruments are fully standardised as to type and size, and every standard panel can be equipped with all instruments necessary for the fullest control of the circuit to which the panel may be applied.

THE GERMAN COAL INDUSTRY.

ACCORDING to the report of the Reich Coal Council, the German production of coal for 1921, exclusive of the Saar district, amounted to about 136,000,000 tons, some 5,000,000 tons, or about 4 per cent. more than that for the previous year. The Ruhr district showed an increase of about 6,000,000 tons, but on the other hand that of Silesia, owing to the disturbed political conditions, declined by 2,000,000 tons. The production of coke amounted to 27,300,000 tons—an increase of 2,800,000 tons, or 11·5 per cent. as compared with that for 1920. Compared with the pre-war production (1913), also exclusive of the Saar district and Alsace-Lorraine, the production of coal has decreased by 21·5 per cent. and that of coke by 9·4 per cent. On the other hand, the production of lignite has increased by about 40·9 per cent. in comparison with pre-war production, and amounted for 1921 to 123,000,000 tons, which is 11 per cent. more than the figure for 1920.

The increase in the number of employees, which for the Ruhr district amounted to 61,000 hands in 1920, has continued, but at a more moderate rate. For the above-mentioned district the increase amounted to about 25,000 hands for 1921, making the total number of employees in the Ruhr district some 557,000, as compared with 390,000 in 1913. In Upper Silesia the number of hands employed has remained fairly stationary at 185,000. For the Ruhr district there is a slight improvement in the output per man, the number of hands having increased by 4·7 per cent. and the output by 6·9 per cent., compared with 1920. The Ruhr production for January, 1922, exceeds by 20,000 tons that of January, 1920, when overtime was worked.

Germany's supply of fuel, it is said, has not really become more adequate; the railway strike brought about a very serious shortage in certain districts. The work of remedying this has been impeded by the lack of locomotives, and this in turn is explained to some extent by strikes. Moreover, the proper quantity of coal has not been delivered to the Allies, February deliveries being about 700,000 tons short owing to railway trouble.

It is urgently necessary, the report continues, to increase the German coal production, particularly as the time is approaching when the Upper Silesian coal mines will pass into the hands of the Poles. To effect the increase will necessitate the adoption of rational overtime work. At the instance of Herr Stinnes, a special Coal Price Committee has been appointed, as the price of coal has not kept pace with the increase in wages and other costs. In the Ruhr district, from 1914 to February, 1922, wages had increased 32-fold, cost of materials 35-fold, but the price of coal has only increased 30-fold.

The new coal tax which came into operation on April 1 will further increase the cost of coal to the consumer, as also will the increase in the turnover tax. Imports of foreign coal, in spite of the extremely low exchange value of the mark, are increasing, and amounted to 48,000 tons in November, 320,000 tons in December, and 180,000 tons in January. A considerable quantity is imported from Czecko-Slovakia.

STORING PULP IN WATER.—An interesting investigation recently completed at the Forests Products Laboratories of Canada, which is likely to have important practical results, relates to the prevention of decay in stored ground wood pulp used in the manufacture of newspaper. The laboratories, basing their experiments on the fact that wood submerged in water is immune to fungal decay, have investigated the preservative effect on pulp of storage in water and have found this method to give results so favourable as to warrant a trial on a commercial scale.

FILE-CLEANING AND SHARPENING MACHINE.

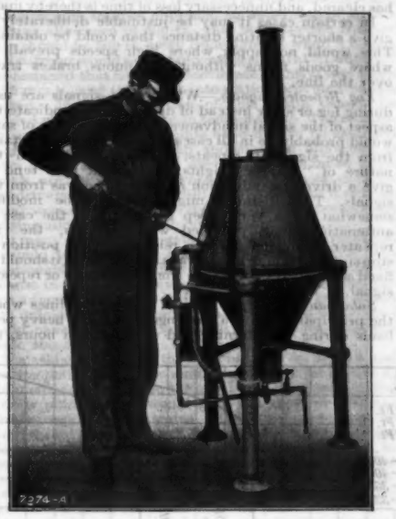
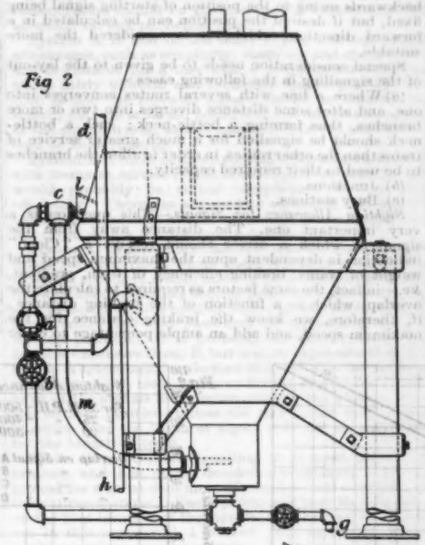
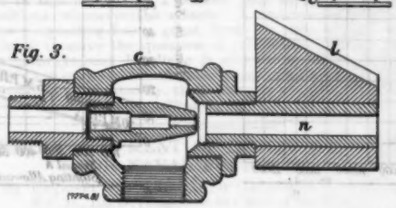


Fig. 1.





A machine for cleaning and sharpening files is illustrated in the accompanying figures. It is intended for use in engineering shops, but is by no means suited only to large establishments, and is claimed to be a profitable investment even in shops in which not more than 10 dozen files are used in a year. On this quantity the makers state 20 per cent. interest on the investment can be earned. Ten dozen is, of course, a very small number of files for an annual consumption, and in all ordinary cases the machine would deal with enormously more than this. The machine, which is known as the "Buckeye," differs from the generality of file-cleaning machines in that a jet of water is used together with the abrasive material, so as to ensure complete cleaning and cutting, and at the same time avoid overheating of the file, or the raising of dust.

The general appearance of the machine is well shown in Fig. 1, while its size is indicated by the operator standing alongside. The details of construction will be followed from Figs. 2 and 3. The file which is being treated is held on an angle block *l*, which is fixed in front of the nozzle chamber *c*. The position of this block and nozzle chamber on the machine are indicated in Fig. 2, while a section of this detail to a larger scale is given in Fig. 3. The block is shaped so that the file is held at the correct angle for cutting or cleaning. The machine may be operated either with compressed air or steam, the connection being made to the pipe *d* which leads to the nozzle inside the chamber *c* by way of the stop valve *a*. A pressure of 50 lb. or 60 lb. is sufficient when files have only to be cleaned, but when they have to be re-cut a pressure of 120 lb. is desirable, although 100 lb. will serve.

The water connection to the hopper of the machine is through the pipe *g* and the overflow through pipe *h*. The abrasive, which is a form of carbon grit is carried in the hopper in a wet state and is drawn, along with water, up the pipe *m* by the action of the nozzle. It is delivered through the orifice *n* on to the file. Arrangements are made to agitate the abrasive in the hopper by admitting pressure steam or air through a pipe; as this agitation is not required continually, the cock *b* is fitted to control it. The abrasive material after passing over the file returns to the hopper and is used over and over again until it becomes too small and light for cutting, when it is washed away with the surplus water through the overflow *h*. The water jet prevents free dust being formed in the upper part of the hopper and only surplus air goes out by the chimney. The machine may be used for sand-blasting small castings, &c., and a door is provided through which they may be inserted. The agents for the machine, who have the sole selling rights for the British Empire, are Messrs. Ronald Trist and Co., Limited, of 12, Clipstone street, Great Portland-street, W. 1.

America and Messrs. Schneider and Co.'s Works.—According to *The Iron Age*, New York, Messrs. J. P. Morgan and Co. have been offering, at a price approximating par, an issue of 10,000,000 dols. 7½ per cent. bonds of Messrs. Schneider and Co., the well-known French steel manufacturers, whose principal works are at Creusot.

LOCATION OF SIGNALS AS AN AID TO TRAFFIC WORKING.*

By R. S. Proud (Associate Member).

The object of this paper is to bring to the notice of the members some of the methods used when deciding upon the best location for signals, especially where automatic signals are to be provided; and in view of the likelihood of automatic signals being installed in increasing numbers in the near future, due to the more efficient and economical traffic working thereby gained, it is hoped that the opinions expressed will stimulate a discussion and bring forward various ideas on this very important subject.

It is becoming more generally recognised every day, that to get the full benefit from a signalling system, it should not only be a thoroughly reliable "safety first" installation, but also one of the greatest aids to the expeditious working of traffic; thus increasing the carrying capacity of the railway. To achieve this object, careful consideration should be given to the locating of all signals. With the present high and sometimes prohibitive cost of widening or duplicating railway lines, it becomes more and more essential to consider and develop this secondary factor, as a well-laid-out signalling system will often delay the necessity of widening a line for very many years.

Although this paper refers primarily to automatic signal location, many of the remarks and methods advocated apply equally well to mechanical signalling, but unless otherwise stated it is assumed that: (1) The line is track-circuited throughout; (2) power automatic signals are installed, except at the commencement and end of the automatic territory; (3) some system of train-stopping device is fitted at all stop signals; (4) overlaps are provided at all stop signals. The object to be aimed at is to locate the signals in such a manner that the desired train capacity is gained at the least cost compatible with safety.

The method advocated is first to study the lay-out of the signals in terms of time rather than distance, viz., to arrange the sections in such a way that a train will take about the same time to travel through each section. After the theoretical positions have been decided upon, the proposed sites will have to be viewed to ascertain whether they are practicable ones. If they are not suitable, due to bad sighting, difficulty of fixing or other cause, the work already done will not be lost, as it will give information as to next best position. There is nothing particularly new in this method, but up to the present it has not been adopted as widely as it deserves, and signal positions are often settled without any reference to the effect on the track capacity. A long section in terms of time may limit the capacity of the whole line.

A graphical method is usually adopted for ascertaining the best locations, a graph being plotted for the train travelling through the line, the ordinates being used for time and the abscissæ as distance, or *vice versâ*. Before drawing the graph it is best to obtain as much information as possible on the following points:—

1. The number of trains on each line that it is proposed to run, or are likely to be run in the future; and the shortest time interval between trains.
2. Average speed of the trains running over the portion of line, with the maximum and minimum speeds likely to be run; also some idea as to the number of trains of the various speeds.
3. Acceleration and deceleration of all classes of trains.
4. Type of traffic dealt with; and any special class of trains or traffic working.
5. Length of average station stop in time.
6. Physical characteristics of the line, such as gradients, curves, cuttings, banks, viaducts, tunnels, lay-outs of junctions and yards, single lines, bottle-necks, &c.
7. Places where special speed restrictions are to be observed.

The headway or number of trains per hour to be catered for should take into consideration the probable growth of traffic in the future; but at the same time it would not be economical to provide for a much greater train service being run than is ever likely to be required—this is a matter for the traffic department to decide. When this question has been settled, the signal engineer should lay out his signalling to cater for a somewhat more frequent service than is actually required. This would allow a margin for the trains to recover lost time after a long delay due to a breakdown or other cause, such as a temporary speed restriction due to a permanent way alteration; or should it be required to increase the number of trains for some special occasion. This small margin gives an elasticity to the system which is at times of great value.

Having decided upon the headway, the next step is to consider the information required in item 2. If there is a great difference in speed, it would be best to consider the average speed of the slower passenger trains, as if the signalling allows these to pass through the section quick enough, it will be sufficient for the higher speed trains, and slow goods trains are not likely to be run when the passenger traffic is at its heaviest. Particulars of the high speeds will also be required to calculate the overlaps. These speeds will have to be obtained by means of observations on the ground, or by recording instruments on the trains; and, where the physical characteristics of the line vary, observations should be taken at various points to ascertain how they affect the speeds.

Each time section consists virtually of four parts, viz.: (1) Sighting allowance for signal; (2) distance between signals; (3) overlap; (4) length of train. The sighting allowance is the distance between the signal and the point at which a driver will commence to check his train if the signal is at "danger." The signal should, therefore, always be at "Clear" when a train reaches that point. This distance, of course, varies with the speed. An overlap is the distance between a signal and a point beyond it, at which the signal in the rear clears; and is based on the braking distance required to stop a train at the maximum speed reached at the signal, the influence of gradients on the braking being taken into account. A factor of safety should be added to this figure to cover exceptionally high speeds, or brakes being out of adjustment. This question becomes a very complicated one where large variations occur in the type and braking efficiencies of the trains. The length of train will be required as each time section is calculated from the time the front of train is "sighting" distance from a signal, to the time when the rear of train passes the clearing point of the signal.

The speed time curve can now be plotted, and this will show graphically the position of the train as it travels through the section of line; and takes into consideration variation of speed due to gradients, curves, permanent speed restrictions, &c. This graph should be compiled as carefully and accurately as possible.

Fig. 1 shows such a graph which is compiled by starting from some fixed point and plotting, to suitable scales, a curve representing the distance travelled by the train from zero, after different intervals of time: if the curve indicates the position of the front of the train, a similar curve, separated from the first by a distance equal to the scale length of train, will represent the rear of train. The graphs in question are for a train travelling up a steep grade at 20 m.p.h., and after about half a mile, reaching the top and accelerating up to 35 m.p.h., then braking to a stop in the station; and after 50 seconds, starting up again, reaching 30 m.p.h. Particulars of acceleration, &c., are given on diagram. Signalling is to be provided for a 3-minute service, but as it is assumed that the service may want to be increased somewhat in the course of a few years, provision should be made for a headway of, say, 160 seconds.

We are now in a position to lay out the signal sections, and the first consideration will be the points at which signals will have to be fixed regardless of track capacity such as junctions, stations, &c. Whilst it is not absolutely essential that signals should be provided at stations if there are no points, it is preferable to install at least starting signals, and in most cases home signals.

Starting Signal Sections.—Where no junction occurs, the section controlling the starting signal should be somewhat longer in terms of time than the intermediate sections, but still keeping it less than the actual headway required. This will ensure, as far as possible in normal working, that once a train was started from a station it will not be checked by signal. This section would thus tend automatically to respace the trains at regular intervals if they had become somewhat bunched up; also, if a check or stoppage took place it would be most likely to occur at a station, which is preferable, especially during the night, or in foggy weather, when there is the

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* Paper read before the Institution of Railway Signal Engineers on Thursday, April 20, 1922.

possibility of passengers mistaking the stopping place and attempting to alight. If the station platform is the full length of the longest train, the best position for the starting signal will be about 100 ft. beyond the platform, except in the case of a very frequent train service, when this distance should be decreased. If the platform is short, the best position will be at a point measured from the rear end of the platform equal to the length of the longest train to be accommodated, plus about 100 ft. This will allow a train which is too long for the platform to draw ahead and bring the rear coaches into the platform without passing the starter.

The starting signal position can, therefore, be plotted on the graph. The length of section, as explained previously, should be longer than for an intermediate signal, in this case about 140 seconds. To obtain the position for clearing point of signal A, draw a line vertically from the point where front of train is starting up, and measure off 140 seconds; project a line from this point horizontally to the right and where it cuts the rear graph at point *a*, project a line downwards, and this will be position of clearing point of signal A. The overlap on the starting signal can be plotted in, and should be sufficient for the highest speed of trains which do not stop at the stations. This position *b* will be the clearing point of home signal B.

Home Signal Location.—As the section controlling the home signal will include the time spent by the train

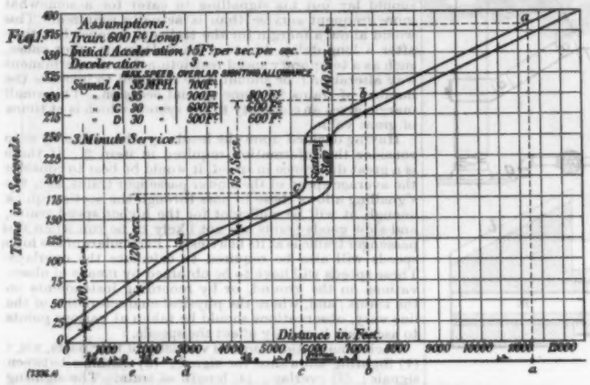
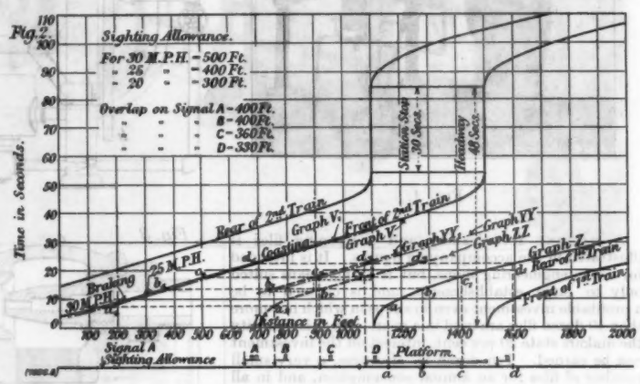


Fig.1.
Assumptions.
Train 600 Ft Long.
Initial Acceleration 1½ Ft per sec. per sec.
Deceleration 3 " " " "
MAX. SPEED. OVERLAP. SIGHTING ALLOWANCE.
Signal A 35 M.P.H. 700 Ft. 500 Ft.
" B 35 " 700 Ft. 400 Ft.
" C 30 " 600 Ft. 600 Ft.
" D 30 " 500 Ft. 500 Ft.
3 Minute Service.
Time in Seconds.
Distance in Feet.
120 Secs.
100 Secs.
157 Secs.
Station 60 Secs.
140 Secs.
73 Secs.



stopping at the station, shown in Fig. 1 as 50 seconds, it is best to make this section as short as possible in terms of distance; unless the station stop is short, and the time between trains is long. This can be done by putting the clearing point *c* of the intermediate signal C close to the platform, say, 100 ft. or less, in the rear of same: the position of home signal B would then be overlap distance from that point.

From signal B measure off a distance in rear of same equal to the sighting allowance, and from that point draw a vertical cutting "the front of train" graph, then the vertical distance from there to an horizontal line drawn through point *b* will represent the length of the home section in time, in this case 157 seconds; and as a three-minute service is to be catered for, it is evident that the station stop must not be longer than 73 seconds. It will be seen that the time section controlling the home signal is made up of three compartments, viz.: (1) Running-in time from the sighting point of the home signal to stopping in station; (2) Duration of the station stop in time; (3) Time taken from starting up of train until the rear of same has passed the clearing point for the home signal.

Where lines are to be signalled for a fairly frequent service, it will be found that the home section will generally be the limiting section for the line. This is particularly so in the case of rapid transit lines, and I wish to refer later to some of the means used to overcome this difficulty. Short platforms tend to aggravate this trouble, due to a long train having to draw up twice to bring all the coaches opposite the platform, thus adding to the length of the station stop.

Intermediate Signals.—It is sometimes usual to fix an intermediate signal for one road opposite a signal for the other road; and while, no doubt, this is often an economical arrangement so far as construction is concerned, it should not be done unless it coincides within a short distance of the best position from a traffic point of view. Local conditions must be kept in mind all the time the signalling is being laid out; for instance, in the case of a long up-grade, it would be more economical to make these sections shorter in terms of time than those on the level, in order to minimise as much as possible the chance of a train being stopped on a gradient, with consequent loss of time and energy, due to the difficulty in restarting a heavy train. A train berth sufficient to accommodate the longest train should be provided in the rear of all signals.

Referring again to Fig. 1, it is now possible to plot the position of signal C. From clearing point *c* draw an horizontal line; from this measure downwards a distance representing the time required for the section (in this case 120 seconds), and from this point draw an horizontal line until it cuts front of train graph; project to the abscissa axis, and this represents the sighting point for signal C; from this point measure a distance towards B equal to the sighting allowance required; this will determine situation of signal C. In the same direction measure another distance equal to the overlap required, this will constitute the clearing point of signal D. In the same way signal D position can be plotted, but in this case the time of section

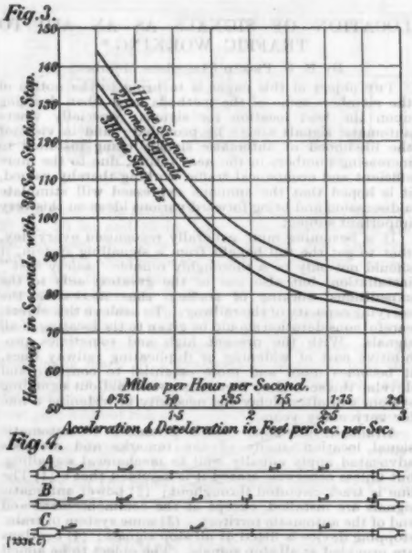
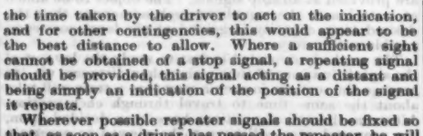


Fig.3.
Headway in Seconds with 30 Sec. Station Stop.
1 Home Signal.
2 Home Signals.
3 Home Signals.
Miles per Hour per Second.
Acceleration & Deceleration in Feet per Sec. per Sec.



should be decreased to say 100 seconds, owing to the presence of a steep up-grade, and the inadvisability of stopping a train on an up-grade, as mentioned previously. The above signals have been laid out working backwards owing to the position of starting signal being fixed, but if desired the position can be calculated in a forward direction, whichever is considered the more suitable.

Special consideration needs to be given to the lay-out of the signalling in the following cases:—

(*a*) Where a line with several routes converges into one, and after some distance diverges into two or more branches, thus forming a bottle-neck; such a bottle-neck should be signalled for a much greater service of trains than the other routes, in order to allow the branches to be used to their required capacity.

(*b*) Junctions.

(*c*) Busy stations.

Sighting Allowance for Signals.—This question is a very important one. The distance away from the signal at which a driver should receive a "Clear" indication is dependent upon the maximum speed and weight of trains, braking efficiency of train, gradient, &c.—in fact, the same factors as required to calculate the overlap, which is a function of the braking distance; if, therefore, we know the braking distance for the maximum speed, and add an ample percentage to cover the time taken by the driver to act on the indication, and for other contingencies, this would appear to be the best distance to allow. Where a sufficient sight cannot be obtained of a stop signal, a repeating signal should be provided, this signal acting as a distant and being simply an indication of the position of the signal it repeats.

Wherever possible repeater signals should be fixed so that, as soon as a driver has passed the repeater, he will be able to sight the stop signal, thus having a continuous indication of the signal aspect; if there is a gap between passing the repeater and sighting the stop signal, the aspect of the latter may have changed, either having "cleared," in which case time has been lost by slow running; or if for any reason the signal has been returned to "Danger," the driver may have difficulty in avoiding overrunning it. It might be an advantage in some cases to install an additional repeater.

The above remarks apply to the distance away at which a driver should receive a "Clear" indication, and not to the distance away that a signal should be actually visible; and while it is essential that a driver should see a signal in plenty of time to act, too long sight of same may lead to unnecessarily slow running, due to a driver slowing up, for instance, when he sees a signal at "Danger"; whereas, perhaps, he could run some considerable distance at normal speed and still have ample margin for stopping; in the meantime probably the signal has cleared, and unnecessary loss of time is thereby made.

In certain cases it may be justifiable deliberately to give a shorter sighting distance than could be obtained. This would not apply where high speeds prevail, or where goods trains without continuous brakes travel over the line.

Fog Repeater Signals.—Where light signals are used during fog or snow instead of detonators, to indicate the aspect of the signal in advance, the best position of same would probably be in all cases at a definite fixed distance from the signal it repeats, as these are more in the nature of "marker" lights, and would thus tend to give a driver an indication of how far he was from the signals. This distance might, perhaps, be modified somewhat for a very steep gradient. In the case of automatic signals provided with overlaps, the fog repeater should be fixed in relation to the position of stop signal. Where no overlaps are provided, it should be fixed at or a certain distance from the distant or repeater signal.

Suburban and Rapid Transit Lines.—On lines where the principal traffic is a passenger one, with heavy peak loads during the morning and evening rush hours, the need for studying the signalling lay-out becomes acute. The signalling through stations in most cases will become the principal problem. Some of the factors, however, are altered; for instance, the speed and class of train to be catered for will probably be fairly uniform, and the acceleration and deceleration nearly constant. On the Underground Railways this question of the signalling through stations has received very great attention, and an attempt made to nullify the effect of the station stop as much as possible by the installation of extra home signals, which clear as the preceding train leaves the station. As many as four home signals have been provided at one station.

The position of these signals affects very considerably the results obtained, and Fig. 2 shows the form of graph used in the study of the best lay-out. The position of the starting signal should be fixed first, in this case about 50 ft. beyond the platform, provided platforms are about the same length as the trains; this allows the clearing point of signal D to be settled, viz., overlap distance beyond the starter. On the Underground Railways the overlaps are based on the average braking efficiency of the trains, allowance being made for the gradient beyond the signal, and to this distance is added another 30 per cent. to cover contingencies; but in the case of starting signals at stations where all trains stop, an overlap is provided sufficient for about 10 m.p.h.

The length of train berth is the next item to settle. This will extend from the starting signal to the end of overlap on signal A, and should be about 50 ft. to 100 ft. more than the maximum length of train. If the train berth is only just sufficient to accommodate a train, it will mean that all drivers must pull up at one definite spot; and unless a certain latitude is allowed, they will be afraid of overrunning the mark, and therefore come into platform slower than is necessary, thus losing very valuable time. Having decided on the length of berth measure that distance in rear of the starter, and it will give the end of overlap on the outer home signal A; measure back the overlap distance, and this fixes the position of signal A. A repeating signal should be fixed under same which would only show "Clear" when all home signals are clear. The time distance curve Z for a train leaving the station should now be plotted, starting from a point about 1,100 ft. from zero. With one home signal, the time from the starting up of train to the home signal clearing will be the time taken by rear of train to clear point *d*. In order to allow a following train to arrive into station quicker, this time must be decreased, and more home signals installed.

Assuming the Installation of Four Home Signals.—The first clearing point to be decided upon will be for signal A, and this should be fixed just under the longest train distance from starting signal, so that if a train pulls right up to starter, it will hold the home signal at "Danger," but will clear same very quickly after starting up. Signal B will be fixed overlap distance from this point. With shorter trains pulling well up to starter, they would clear point *a*, and therefore signal B would become the normal home signal.

Draw a vertical line from *a* cutting the graph Z at a_1

and an horizontal line through that point. If the sighting point of signal A is projected on to this line, we now have a position from which we can plot in a trial graph V_1 to represent the front end of the following train, assuming this train is approaching at 30 m.p.h. with a sighting allowance of 500 ft., that is to say the front of train should be 500 ft. away from signal A when it clears. As the driver would see the repeating signal at "Caution," it is assumed that he would decelerate slightly, say, down to 25 m.p.h., and then coast into station provided signals cleared. The final position of this graph cannot be decided yet, but can be put in temporarily. The remaining signals and clearing points have now to be arranged so that a sufficient overlap and sighting allowance is given on all signals. The overlaps of the inner home signals are reduced somewhat, as it is most unlikely that drivers would run in at full speed unless the repeating signal were clear. As the speed of train decreases the sighting allowance can also be decreased.

In many cases the theoretically best position for signal D would be inside the station; but in practice it is questionable whether this would be a good arrangement, because in the unlikely event of a train being stopped at such a signal, part of the train would be in the station and part outside. It is assumed, therefore, that this signal would never be fixed more than a very short distance inside the station.

A method for finding the best position for signals and clearing points is to draw another graph Z Z parallel to Z, but at a distance equal to the overlap to be allowed at the various points; this would give the shortest distance permissible between trains. Sighting must also be allowed for, and a graph Y Y should be drawn sighting allowance distance from V_1. It is now required to arrange the signals in such a way that the time taken by the first train to travel from one clearing point to the next, is the same as the time occupied by the following train in travelling from one sighting point to the next. This can be done by trial and error, or by further graphical construction, as shown in Fig. 2. From the point a_2 draw a vertical cutting Y Y, whence draw an horizontal line cutting Z Z. From here draw another vertical as shown cutting Y Y, and from there an horizontal. From d project a vertical line cutting Z at d_1, from there draw an horizontal cutting Y Y. From that point draw a vertical line cutting the horizontal line previously referred to, as shown. The time represented by the three verticals between graphs Z Z and Y Y should be equal to the time taken by train to travel from a to d. If, therefore, the time represented by the vertical distance between graph Z Z and the last point is divided up equally among the three verticals, we shall obtain points through which another graph Y Y 1 similar to Y Y can be drawn; if now the same process is repeated, it will be found that all verticals keep inside the two graphs. If the two graphs Y Y and Z Z had been too far apart, a similar method could have been adopted, and substracting from, instead of adding to, the verticals, would have given the position of Y Y 1. Measuring back sighting allowance distance from Y Y 1 will give the correct position for the following train graph.

If the vertical lines ($c_2 b_2$) and ($d_3 c_3$) are extended, they will give the position of signals C and D respectively. Extend the horizontal lines ($b_3 b_2$), ($c_3 c_2$) and ($d_3 d_2$), cutting Z at b_1, c_1 and d_1, then vertical lines from these points will give the position of clearing points b, c and d respectively. The points b_4, c_4 and d_4 indicate respectively the position of the front of the second train when signals B, C and D are clear.

Graph V_1 represents the following train approaching station and coming to rest; the continuation of this line vertically represents the time expended in the station, and the time from starting up of first train to starting up of following train is the headway permissible with that length of station stop. To save confusion, only the necessary portions of the graphs have been drawn in.

The acceleration and deceleration of trains has a great influence on the headway that can be obtained. Poor braking means that longer overlaps must be provided, and longer sighting will be required. This question becomes very important where a frequent service is essential. Fig. 3 gives approximate headways possible with various accelerations and decelerations, which have been taken as being the same for the sake of simplicity. It will be seen what an important factor the station stop is, and it would be advisable on all new lines running through a city, or other densely populated area, to have the station track lay-out specially arranged to minimise this; such as an island platform with loop line, so that two trains can be at the platform at the same time. These schemes, however, are outside the scope of this paper.

Speed Control Signals.—The Interborough Rapid Transit Company of New York developed a system for eliminating some of the delay due to station stops, by which a train was allowed to pass the outer home signal when the station was occupied, provided speed was reduced. This is arranged by allowing one or more of the inner home signals to clear a certain predetermined time after the train has passed the signal in the rear. A very interesting article on this subject by W. U. Lynn Patterson appeared in the *Signal Engineer* of February, 1916. A considerable number of articles have been written on the subject of signal location, among which may be mentioned the following:—

J. G. Van Zandt, *Signal Engineer*, April, 1911.
W. H. Arkerburgh, *Signal Engineer*, August, 1911.
H. G. Brown, Institution of Electrical Engineers' Proceedings, April, 1914.

Choice of Systems.—There are many systems of automatic signalling, which may be broadly divided as follows:—

(a) Ordinary two-position signalling, with one stop signal per block section.

(b) Two-position signalling, with overlap extending from one signal to next. Two signals per block section.

(c) Three-position signalling.

The three systems are shown in Fig. 4, and careful consideration should be given as to the best system for adoption on any particular line.

System A is one of the older types, and has many advantages, such as simplicity, elasticity and cheapness; and is suitable for a line with a frequent service, and where fairly uniform and moderate speeds prevail. In such a case the repeater signals should be situated as shown, viz., on separate posts, and not on the same post as the signal in rear, as this has been found in practice to lead to slow running.

System B is more suitable for higher speeds, combined with frequent service; it is more expensive than A and would probably be rather complicated to lay out efficiently. There are always two signals at "Danger" behind a train; this has an advantage where signals are not fitted with a train-stopping device.

System C is the more modern system, and is most suited for main lines, where there is a large variation in type and speeds of trains, and not very frequent service; in which case the signals become practically speed signals, slow passenger trains running to the 45 deg. position, and goods trains and fast passenger trains running to the 90 deg. position. It is probably an improvement on, and less expensive than, B, but is more expensive than A; and it is questionable whether it is suitable for moderately low speed, close headway traffic, due to the likelihood of the signals being more often in the 45 deg. than the 90 deg. position, unless the signals are very close, in which case the berth at signal may not be sufficient for the length of train.

While three-position signalling is in great favour at present, and has many decided advantages, there is ground for a great deal more discussion on the subject of the various systems. Each system will have its influence on the best location of the signals, but the method as set out in this paper will, I believe, help in finding these positions, whatever the system. I consider that automatic signalling has a great future in this country in helping to solve the question of economical working of the railways, and I believe it will not be many years before not only the signals, but simple point lay-outs will be worked automatically, thus enlarging considerably the scope of automatic signalling.

THE DEVELOPMENT OF DIESEL ENGINES FOR NAVAL PURPOSES.*

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THE following remarks on the development of the modern Diesel engine refer for the most part to work which has been carried out in connection with machinery for naval purposes, although it is fully appreciated that, particularly in the last few years, very rapid progress has been made in the development of Diesel engines for the mercantile marine, both as regards reliability and the size and power obtainable.

A brief account of some of the earlier engines tried for H.M. Service and the difficulties met with may nevertheless be of some interest to members of this Institution.

Our first experiment afloat was the fitting of electric generating engines of the Hornsby-Ackroyd type in three battleships as peace installations. These were virtually additional engines to meet abnormal load requirements and were placed on the upper deck, *not* under protection. They were fairly satisfactory only when using clean fuel oils, such as shale or gas oil, and attempts to use the same fuel oil as that supplied for use under boilers were successful only for a very limited period.

However, the obvious advantage of the use of oil engines in being able to provide electric light when steam was down, for executing repairs, or in the event of the steam service being put out of use during action, was demonstrated, and caused them to be further considered for electric generating purposes.

Great efforts were made to enable them to use Texas fuel oil, by warming the oil and filtering it through cloth filters, which virtually amounted to supplying the engine with a refined oil. The experiment could hardly be regarded as satisfactory, the output being reduced with the heavier oil. These engines had each three cylinders, 15 in. in diam. by 15 in. stroke, and ran at 400 r.p.m. The oil consumption was about 0·9 lb. per brake horse-power per hour, and the lubricating oil consumption about 4 per cent. of the fuel oil consumption.

At the end of 1904 the boilers of torpedo-boat 047 required extensive repairs, and the machinery called for considerable overhaul; it was, therefore, decided to see what could be accomplished in obtaining reversible oil-engines to replace the steam machinery. Tenders were invited from firms in this country, but the designs offered and the results guaranteed were so disappointing that it was eventually decided not to proceed further with the matter, as development had then evidently not reached the stage when manufacturers could confidently recommend their offers.

In 1905, when the designs for the Dreadnought were being prepared, it was decided that this ship should be provided with two Diesel engine dynamos, each of 100 kw. capacity, and that she should carry two 50-ft. pinnaces with Diesel engines of 120 b.h.p. running at 400 r.p.m. At that time there was no experience in this country with any Diesel engine which had been run at a speed greater than 200 r.p.m. The oil-engine makers were quite prepared to design the engines to run at 400 r.p.m., which was an important step forward in development, but hesitated to run the air compressor at the same speed, so it was run at one-half the speed of the engine by a chain drive from the engine crankshaft, and the result was, as is often experienced, that the scheme introduced to avoid trouble was the means of causing it. The chain frequently broke, and later the compressor crankshafts broke; the chain drive was eventually replaced by a spur-gear drive which proved more satisfactory.

The engines were designed with the four cranks all in the same plane as in a four-cylinder car engine; the secondary vibratory forces resulting from this arrangement were primarily the source of much of the trouble which arose, and it was not until wooden shores were fitted in the compartment under the engines by the ship's staff, to give more stiffness to the engine bed, that better results were obtained. One of these engines was later replaced by a steam engine. This is not the only case within my knowledge where the failure of a Diesel engine could be fairly attributed to want of stiffness in the foundation. Designs of foundation structures for Diesels have often been based on those for steam-engine practice, and sufficient consideration has not in many cases been given to the very different nature of the loads and of the fluctuation of those loads from those of corresponding steam-engines of similar power. Even now I think the importance of this point is sometimes overlooked, and the failure of Diesel engines is attributed to the engines themselves, when the foundations and not the engines are at fault.

After the Dreadnought came the battle cruisers Indomitable, Inflexible and Invincible, and battleships of the "Bellerophon" class, each ship being fitted with two 100-kw. Diesel engines. In these engines the air compressor was driven from the end of the crankshaft, and with well stiffened seatings the difficulties due to vibration were practically eliminated.

As with all new propositions, with a lack of experience, and a personnel educated on steam plants, difficulties were still quite of common occurrence. Eventually, however, after considerable running experience had been gained, the more serious troubles were gradually eliminated, and fairly satisfactory results obtained. The cost of upkeep was, however, high, and in 1907, when the design of the "St. Vincent" class came to be considered, it was decided to fit only one oil-driven dynamo. This was of 100 kw. capacity, and was an addition to bare requirements for electric power.

Mention has been made of the two Diesel boats which were to be provided for the Dreadnought; these were delivered after much delay, and one was sent to the Dreadnought and the other to the Lord Nelson. Difficulty was experienced in these boats with the reversing arrangements. Clutches and reverse gears were fitted, and the clutches proved satisfactory, but the reverse gear, which was of a type in which several pinion wheels engage two wheels on the inside and outside rims, failed, principally owing to the difficulty of making the pinions take equal shares of the load. In addition to the clutch trouble experienced, the engines were not flexible enough to allow the boats to be easily brought alongside a vessel or a wharf, and were finally removed from the boats and used for experimental purposes on shore.

In the early part of 1911, it was arranged to fit a combination of oil engines and turbines in a torpedo-boat destroyer. Two sets of two-cycle Diesel engines, each with four cylinders, were to be fitted immediately forward of the turbine engine-room, and geared to the corresponding turbine shafts, helical gearing being used. Clutches were to be provided for disconnecting when not in use. The maximum number of revolutions of the Diesel engine was to be 325, to be reduced by gearing to 260 revolutions, corresponding to a speed of 15 knots. The power of each engine was to be 850, the total 1,700 b.h.p. The Diesel engines were to be used for cruising speeds. Unfortunately difficulties were experienced during the manufacture, although the very best help was obtained by the firm, and the engines were not fitted in the vessel.

The Diesel electric-generating engines previously referred to were not so reliable on service as could be desired, and were not fitted in vessels built subsequent to the "St. Vincent" class; it was not until 1911 that the question of again fitting oil-driven dynamos were considered. During the period which had elapsed experience was being gained, and reports were on the whole becoming favourable. It was generally admitted, if slight modifications could be made which would add to its reliability, the Diesel engine was undoubtedly an acquisition in a ship; its economy was beyond question. The principal difficulties encountered were the cracking of pistons and breakdowns of air compressors which were of the two-stage type. Complaints were also made of noise and vibration, and of the unsatisfactory leads of the exhaust pipes, which passed through living spaces and store rooms.

It is of interest to note that as the *personnel* became better acquainted with Diesel generating engines, the desire for them was in some cases so great that they were preferred to the reciprocating steam-generating engines; the economy was very marked, one ship giving in comparison 35 tons of oil for the Diesel engine against 350 tons of coal for a reciprocating steam engine, doing the same work. As a result of the more favourable reports, it was decided to fit one oil-driven dynamo of 150 kw. capacity to the ships of the 1911 programme, and generally since that time two Diesel generators have been fitted in capital ships. During the war, however, some ships were only provided with one engine, and others with no Diesel engines, but this was often a question of obtaining machinery of this type in sufficient time.

To-day, although it cannot be stated that the oil engines are as reliable as the steam turbo plants, the results are on the whole satisfactory. The upkeep, however, is greater, but the gain in economy outweighs the other disadvantages, as already indicated. There is no doubt that the advent of the steam turbine caused

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the development of the oil engine to be much retarded, and the increase of power demanded with limited weight has become so enormous that it is impossible at present to consider oil engines for the propelling machinery of large surface warships.

For moderate powers and comparatively low speed of revolution, such as are required for many merchant ships, where head-room and space are not so limited as in warships, there has been considerable development, and the large number of Diesel-engined ships now in use and building is an indication of the increased reliability expected and being obtained.

The manufacture of Diesel engines demands in many respects a higher standard of workmanship than the reciprocating steam-engine, and what is even more important, a better education of the *personnel*. In some details this high standard of workmanship is not required, and if maintained throughout it adds to the cost without adequate return, with possibly some disadvantages, and it is in my opinion questionable whether, if a mixed standard can be permitted, it would not be advantageous from the competitive point of view. In our own Admiralty work, where we join to the full in requiring a very high standard for the vital parts, we are rather encouraging a lower standard for the less important parts. We believe that we shall get cheaper engines without detracting in the least from their efficiency, reliability, or durability.

Undoubtedly there has been, and there still exists, some prejudice against the Diesel engine, and whilst some of this may be due to lingering doubts as to its absolute reliability, it is also largely a prejudice against reciprocating engines which quickly developed when steam-driven-engines of this type were displaced by the steam turbine, the relative advantages of the latter being enhanced by the advent of the oil-fired boiler.

About the end of 1911, in view of the oil fuel requirements of the Fleet, it was decided to build a number of oil-tank vessels, and arrangements were made to fit Diesel engines in five of these ships, the brake horse-powers of the various types of engines being 450, 1,500 and 2,500 respectively. Many serious difficulties were experienced with these engines, from time to time, but valuable information and experience were obtained as regards the nature of the problems to be solved both with respect to material and the training of *personnel*.

During the foregoing period consideration was given to what might be accomplished in various types of ships fitted with oil engines and combinations of oil engines and turbines, for propulsive purposes. It was in view that the comparatively low-powers required for economical speeds could be obtained by using oil engines, and the powers required for higher speeds obtained by using the less economical turbine-plants. In a vessel designed for four propeller shafts, oil engines would have been fitted on two of the shafts and steam turbines on the others. During this period the powers of the capital ships of the "Queen Elizabeth" class had risen to 70,000 s.h.p. at full speed, making the problem of fitting oil engines very difficult, and still more difficult when the power was further increased in later vessels, although the reduction of power for the "Royal Sovereign" class made things easier. It is of interest to note in the combination arrangements that the oil engines, if designed for the full-power requirements of the ship, could not obtain their full power at lower speeds if used alone, the revolutions being reduced even if the mean pressure obtained in the cylinders were the maximum. These considerations, together with proposals to drag the idle screws of the turbine shafts, very considerably reduced the speeds which could be obtained with oil engines only on two shafts.

Owing to the outbreak of war the proposals were not persevered with, but others were made, however, in the design stage of the Hood to fit an oil engine of 1,200 h.p. on a centre shaft. This was increased later to 4,000 h.p. (to develop 3,000 h.p. at 185 r.p.m.), and the final proposal was to fit two sets of eight-cylinder engines, each of 4,500 h.p. running at 185 r.p.m. on the wing shafts, with three sets of turbines on the centre shafts. These proposals were subsequently abandoned.

In one of the oil-tank vessels, six-cylinder engines of the M.A.N. two-stroke cycle design were to be fitted. They were, however, fitted in the monitor Marshal Ney. These engines gave considerable trouble, chiefly due to errors in design, but although they were of the two-cycle type, it is considered that the want of success was not in any way due to the fact that the two-cycle principle was involved.

For another tank vessel the machinery was made by Messrs. Vickers, and the engines were fitted with that firm's solid-injection system of fuel supply to the cylinders. No arrangements were made for cooling the pistons. Two independent air compressors were fitted to charge the reservoirs for the main-engine starting air. As in the previous installation, all the other auxiliaries were steam driven, and two Yarrow oil-fired boilers were provided for this service.

During the trials it was found difficult to obtain the guaranteed fuel consumptions; this was due to the measuring device, which controls the supply of oil to the cylinders, being fitted at too great a distance from the actual inlet into the cylinder and admitted of what is often described as "dribbling" and the consequent effect "after burning." These engines were designed to use Texas oil-fuel as usually supplied under the boilers.

After the shop trials the engines were placed on board the oil-tank vessel Trefoil; the vessel was practically complete and ready for trials, when the machinery was ordered to be removed and fitted in a second monitor, the Marshal Soult. Satisfactory sea trials were made, although the speed obtained was only about 5 knots; the engines were running at maximum revolutions, but could not develop the full horse-power. When the slip of the propellers had been altered, the full power was obtained, with the result that the speed of the ship was increased to 6½ knots. On the whole the machinery would be described as reasonably successful, and I suppose no ship was so often in action as this monitor.

These monitors were manned by naval ratings with R.N.R. engineer officers. There is no doubt that the liberal engine-room complement provided and the opportunities for repair were factors facilitating the upkeep of this machinery.

As the result of the experience in the Marshal Soult, certain modifications, principally in the arrangement of the fuel-oil spray valves, were made on the replace set of engines for the Trefoil, an oil-tank vessel, with the result that there was an improvement in the oil consumption on the trials, averaging 0·47 lb. per brake horse-power per hour against 0·55 on the original set. Other mechanical details were modified, but are hardly of sufficient interest to mention in detail.

Experience on service so far has shown that a considerable amount of work is necessary to maintain the machinery in good working order, although we regard with great satisfaction the fact that this ship did her first 18 months of hard war service without being laid up, and without developing any defects except those that could be made good by the ship's staff. The subsequent cost of refitting has been heavy compared with steam engines of similar power, but we are quite willing to grant that this must be expected in an installation where there are 16 cylinders to the main engines, besides Diesel-driven compressors and the steam plant. These additional costs have, however, been far outweighed by the saving in fuel, in *personnel*, and other advantages.

The machinery for a larger twin-screw oil-tank vessel was made by Messrs. Vickers, and consisted of two sets of eight-cylinder four-cycle engines of a total power of 2,500. I am very glad to say that the trials and subsequent service of the main engines were generally satisfactory. The defects which probably caused most trouble were due primarily to leakage from the glands of the piston cooling pumps, and sometimes breakage of the pump parts; these pumps were of the trombone type.

The salt water finding its way into the lubricating oil, and possibly containing a certain amount of sand, caused the piston rings to be gummed up and admitted of gas blowing past the pistons and gassing the engine-room staff. This leakage became so serious that the engines could not be started by compressed air.

About the end of 1911 arrangements were made for the construction of a single-cylinder experimental engine of 1,000 b.h.p. The engine, which was of the two-stroke cycle type, was made by Messrs. Vickers, and intended finally to form part of a six-cylinder engine of 6,000 b.h.p. The diameter of the cylinder was 30 in., stroke 36 in., and revolutions 140 per minute. Compressed air was used for fuel injection. The auxiliaries were separately driven.

A considerable amount of experiment was necessary, and the final trial took place about two years after placing the order. The engine made a continuous run of 223 hours without stopping, of which time 103 hours were run at full power, 90 hours at four-fifths, and 30 hours at three-fifths; the fuel oil used was Texas oil, having a viscosity of 137 seconds Redwood at 70 deg. F.

The chief features brought out in connection with the experimental work were the difficulties of thoroughly scavenging the cylinder and getting rid of the products of combustion, in keeping the valves, pistons, cylinder liner, and crosshead bearing cool, in designing the cylinder liner, piston, and cover to stand the high temperature, and in spraying the oil so as to produce efficient combustion at the comparatively high mean pressure which was aimed at. The experimental work on this engine gave valuable information applicable to high-power engines of all types.

The mean power maintained during the 103 hours' trial, at full power, was 1,044, and the fuel consumption of the main cylinder alone during this period was 0·405 lb. per brake horse-power per hour. It was estimated that, with the consumption for auxiliaries separately driven, the total for a six-cylinder engine would be about 0·55 lb. of fuel oil per b. horse-power per hour. In addition to this, the consumption of lubricating oil was estimated to bring this total up to 0·6 lb. per brake horse-power per hour, or just one-half the oil-fuel consumption in a turbine installation. The total consumption of oil, including lubricating oil at four-fifths, three-fifths, two-fifths, and one-fifth, based on the trials and other information, was found to be approximately, per brake horse-power per hour, 0·6 lb., 0·65 lb., 0·70 lb., and 0·85 lb. respectively.

The engine at the completion of the trials was considered an efficient working arrangement, capable of producing its full power for a further period, and that similar results could be expected if a multiple-cylinder engine of the same type were designed for higher powers. Moreover, the experience gained during these trials indicated how a combination of units of this type, if used for propelling a ship at sea, could be utilised for a required endurance, remaining efficient without important repairs.

Further experiments were made using Mexican oil, including a run of 90 hours, of which 30 hours were at full power, and the remainder at four-fifths and three-fifths respectively. A mean brake horse-power of 1,043 was realised at full power, and the engine worked satisfactorily.

The immediate cause of stoppage when using this oil was the failure of an auxiliary air compressor, and was not connected with the efficiency of the main engine; but on taking the opportunity of this stoppage to open out the cylinder of the main engine, it was found that there were hard carbon deposits on the piston rings and other parts, that one of the piston rings was broken, and that the engine had practically reached its limit of work. If the stoppage had not occurred in the way it did, the engine would probably have had to be stopped owing to the difficulties with the piston rings.

Considerable alterations were made in the spraying and oil-supply arrangements during the preliminary experiments to adapt the engine to Mexican oil, and it was found that unless the combustion could be improved and the formation of deposits prevented, working with Mexican oil would not be satisfactory. Further experiments were being carried out raising the Mexican oil-fuel to higher temperatures by placing electrical heaters on the discharge side of the pumps and using solid injection, when the war intervened and prevented any further experimental work in this direction. The trials strongly impressed on my mind that, when developments of this kind in the Diesel engine are in progress involving engineering consideration, thought, and skill of a very high degree, the commercial idea of using cheaper ones, probably unsuitable for such developments, should not be simultaneously pressed from other directions. The field for the experimental use of cheap oils is in engines which have passed through the trial stage; the experimenting engineer should not be hampered and embarrassed while more important and high-class engineering trials are in progress.

At the end of 1912 it was pointed out that the close attention given by Continental engineers and manufacturers to the development of the Diesel engine for many years past had enabled them to accumulate a large fund of information, from which not only had there been a continuous development in size, economy, and reliability, but the methods of manufacture had also developed simultaneously, resulting in rapidity and cheapness of output. Having little of this experience, which could only be obtained first hand by laborious and patient research, our manufacturers were handicapped in comparison with these Continental firms.

To be of effect in the competition they had to purchase licences from these Continental firms at high cost, and although this provided them with certain standard-working designs, it did not furnish them with the necessary experience to develop from these standards. There were also indications that British manufacturers had not realised that a higher standard of workmanship was required for the essential parts of these engines than that for the ordinary types of marine steam-engines, nor were many of them equipped with the special tools and appliances necessary for securing such higher standard. It was confidently expected that they would overtake these arrears and eventually put themselves on a level or become superior to their Continental rivals in due course, but for some time they were at a disadvantage.

In these circumstances there was reason to believe that the Admiralty would derive considerable benefit by obtaining Diesel propelling-engines for three 10,000-ton tankers direct from the best of the Continental firms. The machinery would in this way be otained in shorter time, and with other advantages of considerable importance. In addition, by the close touch of our inspecting officers with the detail design and the methods of manufacture of the several items, sources of information would become available and an accumulation of particulars would be obtained at first hand that would be of great value to the service and for future manufacturers, and which it would be difficult to obtain in a short time in any other way. The ordering of machinery from foreign makers would undoubtedly have had the effect of stimulating the development of this newly-started industry in Great Britain, and would ultimately have been regarded as having been a beneficial step in its progress. Arrangements were accordingly made to obtain from Messrs. Carels, Sulzer and the M.A.N. Company machinery to the following requirements:—

Two sets, one right-handed and one left-handed, controlled from a position between the engines of two-cycle single-acting reversible Diesel engines of their own highest-class manufacture, for placing in a ship to drive twin-screws, and to develop in the aggregate about 3,200 b.h.p. (1,600 b.h.p. for each screw) at about 120 r.p.m. to 130 r.p.m. The number of cylinders were to be as small as consistent with experience.

The horse-power and revolutions stated were to be regarded as approximate, and machinery developing rather different power, and running at a somewhat different speed of revolution, would be acceptable if more in accordance with their standard manufacture. The machinery was to be provided with all the necessary accessories for scavenging, fuel injection, and starting the engines, and with silencers, circulating engines, lubricating pumps, pipes, oil heaters, fittings, &c., that would be required for use with the main engines when fitted in a twin-screw ship, and these accessories were to be used during the trials of the main engines in the shop.

It was preferred that the engines should be of the open type with piston rods and crosshead guides, and separate cylinder liners. Alternative arrangements, however, could be forwarded if desired. Special attention was to be paid to the necessity for ready access to all parts for overhaul, adjusting, and repair. The cylinders, pistons, valves, connecting rods and all corresponding parts of the engine were to be interchangeable among themselves, and firms were required to demonstrate that this provision had been fulfilled in connection with any parts selected. All necessary gauges, trammels, &c., for adjusting the various parts after overhaul were to be supplied.

The engines being required for marine purposes, it was considered of great importance that there should be a great range of speed variation, and the capabilities of the engine in this respect were to be stated. The design of the engine was to be such that vibration was reduced to a minimum, and curves of vibrating forces and couples, together with curves of turning-movement were to be forwarded.

A 48 hours' continuous full-power trial was to be

carried out in the shops with each of the engines to satisfy the inspecting officers that the brake horse-power specified could be developed satisfactorily. Trials were also to be required to ascertain that the arrangements for starting, running at slow speeds with all cylinders firing, stopping and reversing, would meet marine engine requirements. During the full-power trials the fuel and lubricating oil consumption were to be measured, and the usual trial records taken. The trials were to be carried out with Texas residual oil-fuel, and the engines were to be capable of using oils of higher viscosity.

After delivery in this country, the engines were to be erected on board by the builders of the ship under the supervision of the engine makers' representative, who would also attend and supervise the trials in the ship, so far as the parts supplied by the engine makers were concerned.

Some of the members may remember seeing one of the Carels engines at the Ghent Exhibition in 1913,* which, with slight modification, was to form one of the parts of the set. Unfortunately before delivery of Messrs. Carels' engines or those from the M.A.N. Company could be made, war broke out with Germany, and neither of these engines was delivered. The Sulzer engines were delivered after satisfactory shop trials. It was hoped to find an opportunity to fit these engines in a suitable vessel; unfortunately this opportunity did not arise.

As regards the Diesel engines used for propelling submarine vessels in H.M. Service, the earlier boats up to and including the "C" class were fitted with petrol engines, and certain disadvantages of this type of fuel made it desirable, even on the score of safety alone, that arrangements should, if possible, be made to use heavier and safer fuel oil. This was carried out in the "D" class submarines, which were fitted with two six-cylinder four-cycle Diesel engines, of 100 b.h.p. per cylinder, with compressed air-injection. A good deal of difficulty was experienced with the air compressors, and in the following classes of vessels air compressors were dispensed with, and the solid injection of fuel (of which system Messrs. Vickers were the pioneers in this country) was employed, the fuel used generally being shale or a similar grade of oil. This was the general position at the time of the outbreak of war, and at that period the Vickers' four-cycle engine, with cylinders 14½ in. diam., 15 in. stroke, and developing 100 h.p. per cylinder at 380 r.p.m., was the only available engine with which there was any extended experience in the service.

At a very early stage in the war it became necessary to standardise engines as far as possible, in order to obtain the maximum rate of production, and in these circumstances engines of the above named Vickers' type became the standard for the propelling engines of British submarines, and were produced in large numbers, both by Messrs. Vickers themselves and also by other firms working under licence. The only development, therefore in this class of engine during the war period was with respect to the number of cylinders employed, the engines in the earlier classes of submarines consisting of twin eight-cylinder units, those in later classes of twin twelve-cylinder units, whilst in still another class triple twelve-cylinder units were fitted.

It will be appreciated that, at least in the earlier stages of the war, conditions did not permit of experimental work being undertaken to any great extent, even if suitable facilities had been available. In the last year or so of the war, however, following on the inauguration of the Admiralty Engineering Laboratory, a certain amount of experimental work was commenced. For obvious reasons, in order not to interfere with the production, these experiments in their earlier stages were confined to the endeavour to increase the power and improve the running of engines of the standard type, whilst departing from the standard design as little as possible.

It must always be borne in mind that for the naval practice we are compelled to obtain the maximum power on the smallest possible size and weight. The Diesel engine still compares unfavourably in regard to weight with the oil-fired boiler and steam-turbine combination, and usually the space available, especially in the direction of head-room, is severely limited. It is in the attempt to obtain the maximum power for a given size of cylinder, combined with good efficiency and reliability, that we have to consider some important features, and on these features a large amount of our experimental work has been based.

As is well known, the factors on which the power for a given cylinder size (*i.e.*, bore and stroke) depend are:—(1) Engine revolutions; (2) the mean pressure developed throughout the working stroke; (3) the number of firing strokes per revolution.

When (1) is considered, it has to be remembered that if the speed is increased beyond a certain figure the conditions are arrived at where the inertia forces may actually exceed the loads due to combustion pressures, and as these latter pressures in general govern the scantlings of important details, the importance of keeping down the inertia forces can be fully appreciated. The solution of this problem led to the use of pistons of aluminium alloy instead of cast-iron. By this means it was found possible to run an experimental engine of very similar design to a standard submarine-engine at a speed approaching 500 r.p.m. (instead of 380 r.p.m. usual with a submarine engine), and to obtain in the experimental engine about 155 b.h.p. per cylinder (as compared with about 100 b.h.p. in the standard engine) without increasing the inertia stresses set up. The use of aluminium pistons enabled connecting rods of lighter section to be used, and, combined with the use of a rod of I-section instead of a circular section, enabled a very considerable reduction of reciprocating weights to be effected. From these reciprocating weights, assuming the same speed of 380 r.p.m. in the two cases, the bearing pressures were worked out for the experimental and the standard engines respectively. These were found to be considerably less for the experimental engine, and the speed being the same in both cases, the reduction is a measure of the increase of the mechanical efficiency, which is estimated at about 2 per cent.

The use of an aluminium alloy for pistons carries with it also a further incidental advantage due to the high thermal-conductivity of the metal. This is of considerable importance in connection with pistons of large size, particularly where internal cooling by the use of either oil or water is necessary. Pistons of such alloys, up to 20 in. diam., have now been run for a considerable period in the Admiralty experimental engines under quite severe conditions of pressure and temperature and up to the present have proved quite successful. Experience is also being gained with pistons under actual service conditions, and their behaviour after a period of continuous service will be a matter of considerable interest.

At about the period when these experiments were reaching an advanced stage it became known that the Germans had under construction Diesel engines, suitable for submarine vessels, developing about 300 b.h.p. per cylinder, and consequently the next step decided upon was to proceed with the design of a single-cylinder unit of about the same power, embodying as far as applicable the results of experience gained with the earlier experimental engine. The dimensions decided upon were 20 in. diam. and 20 in. stroke, with full speed revolutions of 390 per minute, *i.e.*, a piston speed of 1,300 ft. per minute, which was a considerable advance on previous practice.

It was decided to fit a piston of aluminium alloy as in the experimental engine, but in this case arrangements were made to cool the piston internally by the circulation of oil.

The engine has now been in use for experimental purposes for quite a considerable time, and has run quite satisfactorily. In particular it may be mentioned that no trouble at all has been experienced with the aluminium piston, although it has from time to time been subjected to high temperatures and high mean-pressures up to as much as 150 lb. per square inch. Also even at these very high mean-pressures it has been recently found possible to obtain an invisible exhaust.

The reduction of inertia stresses is not the only question that has to be solved in high-speed engines. There are the questions of adequate valve or port area and valve operation, for the induction and scavenging of the gases becomes of great importance, together with the associated questions of cylinder cooling, a greater number of heat units in a given time having to be conducted away as the engine speed increases, if trouble with exhaust valves, &c., is to be avoided. Further development on those general lines is, therefore, largely dependent on metallurgical research in light, high-tensile alloys and materials possessing adequate strength, combined either with good heat-resisting or heat-conducting properties as necessary.

As regards (2), the problem of obtaining the maximum mean-pressure with efficient and smokeless combustion raises the whole question of methods of fuel injection. The fuel on admission must ignite rapidly and burn rapidly without excessive and sudden rise of pressure (referred to as detonation), since late burning has a prejudicial effect on the fuel economy of the engine. To obtain these conditions is no easy matter in high-speed engines. A considerable amount of experimental work has been carried out and is still necessary in this direction.

To meet the general requirements the jet of oil entering the cylinder must be pulverised to such an extent as to present sufficient surface to the compressed air in the cylinder to enable it to burn quickly, but at the same time the jet must have sufficient penetrative power to enable the fuel to reach the position where air is available for its combustion. These two requirements are opposed, as the greater the pulverisation the less the penetrative power. It is still a question that has to be definitely settled whether air injection assists the rapid combustion, or whether the desired results are obtainable with solid injection. It must be remembered that the time available for injection and burning is about $\frac{1}{70}$ of a second, a figure which more than extended description enables the difficulty of the problem to be comprehended.

A consideration of (3) indicates that our desires will not be obtained unless we develop the double-acting two-stroke engine, which, however, subject to our limitations of space, especially in the direction of head-room, opens up difficult questions. I have no intention of raising the question of two-stroke *versus* four-stroke engines, as this has been a well-discussed subject. If we generally favour the four-stroke engine at present, it is because we feel we are somewhat more advanced with this type, and any natural disadvantages that the two-stroke engine is recognised to possess are in general more accentuated when the discussion is confined to very high-speed engines. It will be noted later that we are basing our experiments on the possibilities of trying out single-acting and double-acting two-stroke units in addition to others working on the four-stroke cycle.

Concurrently with the design and construction of the 300 b.h.p. experimental engine for the laboratory, an experimental engine of approximately the same size and power was designed and built for the Admiralty by Messrs. Vickers, and this engine has run successful trials during the last 12 months. A further experimental engine of approximately the same power, but of the "V" type, was constructed for the Admiralty by Messrs. Beardmore, but the trials of this engine, although they are not yet completed, have given very promising results. There is no doubt, therefore, that, should the necessity arise, British engineers will be able to design and construct submarine engines having at least as high power per cylinder as those used in German submarines.

Two-Stroke Cycle Engines.—The foregoing experimental work refers entirely to engines of the four-stroke cycle type, but the possibilities of the two-stroke type have not been overlooked, and an engine of this kind has been constructed by Messrs. J. S. White, and is now installed at the laboratory. This single-cylindered engine is designed to produce 400 b.h.p. at 390 r.p.m., and it is expected that experimental work upon it will provide very valuable data.

Double-Acting Two-Stroke Engines.—A good deal of attention has been directed recently to the possibility of such engines, and a large engine of this type, from which it is hoped that most valuable experience and information will be gained, is already being designed and under construction for the laboratory.

Miscellaneous.—Time does not permit of a detailed description of the large amount of subsidiary work which has been and is still being done at the laboratory in connection with problems that have arisen from time to time in the course of the work with the experimental engines. As instances, however, there may be mentioned an investigation undertaken, with a view to elucidating some of the problems of fuel injection, to determine the influence of temperature on the "time lag" between the moment of injection and the moment when rise of pressure commences; also the trial of various methods of piston cooling, &c., and the determination of certain physical constants and heat data which will be of the greatest assistance in the design of engines of high speed and power.

It can fairly be claimed, therefore, at the present time that, not only has the Admiralty, with the valuable assistance of oil-engine makers, succeeded in removing to a very great extent the reproach that the British Navy was behind some Continental navies as regards the development of oil engines, but that it is in a fair way in the course of the next few years, provided the experimental work can be continued, to take up a position in the front rank of such work which will be worthy of the prestige which British engineering has always maintained in the past.

* See ENGINEERING, vol. xcvi, page 161.

THERMAL CONDUCTIVITY OF CAST-IRON.—The thermal conductivity of iron and steel and its temperature coefficient are uncertain, and most of the observations do not cover wide temperature ranges. Jaeger and Diesselhorst observed a slight fall in the conductivity of pure iron, from 0·161 to 0·151, as the temperature rose from + 18 deg. to 100 deg. C.; Lees observed for wrought iron 0·152 at — 180 deg. C., and for steel a very slight rise with temperature, from 0·113 to 0·115, at — 180 deg. and + 18 deg. C.; Callendar found a slight fall in the thermal conductivity of cast-iron between 54 deg. and 102 deg. C., from 0·114 to 0·112. Experiments on the thermal conductivity of cast-iron at high temperatures are described by Elmer E. Hall in the *Physical Review* of last March. He cast a cylindrical shell, 3 cm. wall thickness, 6 cm. internal diameter, fitted it with a hemispherical cap, charged it with paraffin or fused lead (kept liquid by electric heating), and measured the temperature difference between the inner and outer surfaces of the shells by means of thermo-couples. The shell was placed inside a container of similar shape, the temperature of which was controlled. As the temperature of the inner surface rose from 197 deg. to 545·2 deg. C., *i.e.*, by about 350 deg., that of the outer surface rose from 194 deg. to 538·6 deg. C., and the thermal conductivity rose from 0·0718 to 0·2050. Two independent sets of observations by different experimenters were in good agreement; but it is admitted that the thermo-couple readings had to be continued for many hours before they became constant. The value at 197 deg. is very low and the change large.

EXAMINATION OF STEEL STRUCTURE BY RÖNTGEN RAYS.—The examination of metals by X-rays may be performed for two purposes. When it is desired to discover flaws in the material, the specimen may be comparatively thick and the photographic plate will indicate any differences in the actual thickness of the material due to cavities or cracks by the differences in the density of the deposit; the most penetrating rays are used for this "absorption method." When we wish to study the structure of the metal, thinner specimens must be employed and the most penetrating rays of shortest wave-lengths are less suitable in this case, because diffraction phenomena have to be studied, and the apparent interference fringes would lie too close to the primary spot. For this "interference method" then rays of medium hardness are preferred, though they require longer exposures. At the Röntgen Laboratory of the Technical High School, Stuttgart, Dr. R. Glocker (*Stahl und Eisen*, April 8) prepares, with the aid of an end-mill cutter, disc specimens of steel only 0·25 mm. in thickness. He arranges the X-ray bulb in such a way that two very narrow pencils of rays pass through windows and suitable stops so that two specimens can be examined at the same time. The interpretation of the Laue diagrams obtained by this method is very difficult, and simplifications are desirable in this respect, as well as improvements of the bulb, so as to permit of a better utilisation of the rays. According to P. Wever, α and β iron both seem to have the structure of a space-centred cubic lattice, whilst in γ iron the structure is that of a face-centred cubic lattice. Cooling in liquid air does not appear to change the lattice structure of manganese steel. The changes in structure which one might expect to accompany magnetisation of steel are not distinct in the Röntgen test, but the change of grain size on tempering can be observed in the radiographs, as also can be the differences between cast and rolled materials.

A FURTHER STUDY OF THE ALLOYS OF ALUMINIUM AND ZINC.*

By D. HANSON, D.Sc., Member, and MARIE L. V. GAYLER, M.Sc., Member.

(From the National Physical Laboratory).

PART I.—CONSTITUTION.

Introduction.—The constitution of the alloys of aluminium and zinc has been investigated by a number of workers. Shepherd and Eger published diagrams which indicated that the alloys formed a simple eutectiferous series. Rosenhain and Archbutt showed that the system was much more complex, and that, in addition to the eutectic arrest at 380 deg. C., a peritectic reaction occurred at a temperature of 443 deg. C., at which temperature the aluminium-rich solid solution reacted with liquid, to form another constituent, and the experimental evidence strongly supported the view that this was essentially the compound Al_2Zn_3. Their diagram is reproduced in Fig. 1. It was not claimed, however, that this diagram was complete, particularly with regard to that portion immediately below the line G H; within this region it was not found possible to resolve the alloys into two constituents, in spite of the fact that the thermal data suggested a duplex constitution within this range. The present investigation was undertaken, at the suggestion of Dr. Rosenhain, with a view to investigating further the constitution of the phase known as δ in this diagram, and it has necessarily also involved a study of the neighbouring β and γ constituents. Bauer and Vogel, in 1916, published a modification of Rosenhain's and Archbutt's diagram, which is shown in Fig. 2. They find that the peritectic line C G H extends to approximately 40 per cent. of zinc, and in this they agree with Rosenhain and Archbutt; the horizontal at 256 deg. C. they find to extend to a composition of about 25 per cent. of zinc. Between these two lines they find that the alloys consist of two constituents, Al_2Zn_3 and γ, and that the duplex field is separated from the γ field by the sloping line H L. The resolution of the δ constituent into two substances, in the manner suggested by Bauer and Vogel, appeared to be the simplest solution of the difficulty. Preliminary experiments by the present authors had, however, failed to reveal any duplex structures in alloys, containing up to 60 per cent. of zinc, which had been quenched from a temperature slightly below the peritectic line at 443 deg. C. They did not consider that this was due to the choice of an unsuitable etching reagent, since the crystal structure of the alloys could readily be developed, and they saw no reason for thinking that spurious etching results were being obtained. At the same time, it was realised that such a structure is inconsistent with the existence of the horizontal line G H, and a further investigation of the system in this region appeared desirable.

Preliminary Investigation.—Aluminium-zinc alloys containing between 80 per cent. and 40 per cent. of zinc, when cooled at moderate rates such as those used in the taking of cooling curves, possess, after passing through the critical point at 256 deg. C., a fine "pearlitic" or "sorbitic" structure, which suggests that the whole of the solid solution existing above the line K L had broken up on passing through this line. While the appearance of such alloys does not suggest any prior separation of the solid solution into two constituents, it was thought desirable to subject the alloys to much slower rates of cooling. By this means, it was hoped that any decomposition or precipitation which took place would result in the formation of relatively large particles which would be more readily detected. Two series of experiments were undertaken. In the first series, alloys containing approximately 70 per cent. to 50 per cent. of zinc, after a preliminary annealing at a temperature of 420 deg. C. for 67 hours, to secure homogeneity of composition, were cooled very slowly to 284 deg. C. and quenched. The microstructures of two of these alloys are shown in Figs. 4 and 5 under a magnification of 600 diameters. The etching reagent used was a solution of 4 per cent. nitric acid in alcohol. Similar results can be obtained by the use of 10 per cent. aqueous caustic soda solution, but with the latter reagent it is difficult to prevent pitting and tarnishing of the surface of the specimen; the alcoholic nitric acid reagent is in every way preferable, as the structures produced are developed in a few seconds, and prolonged exposure to the etching reagent does not lead to any visible further attack. The

Fig. 1.

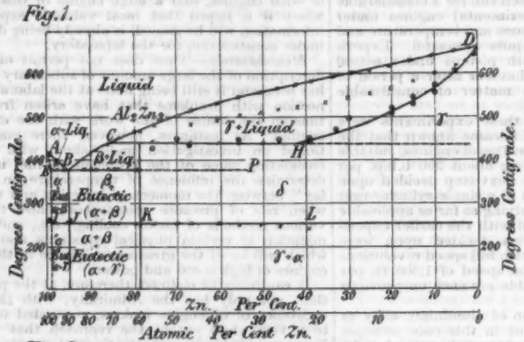


Fig. 2. DIAGRAM OF BAUER AND VOGEL.

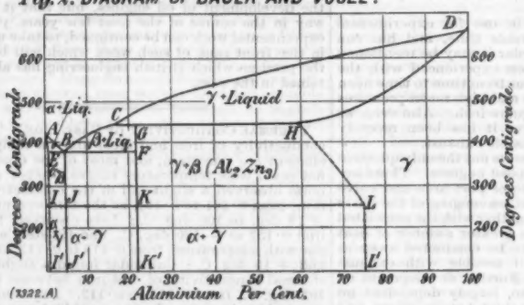
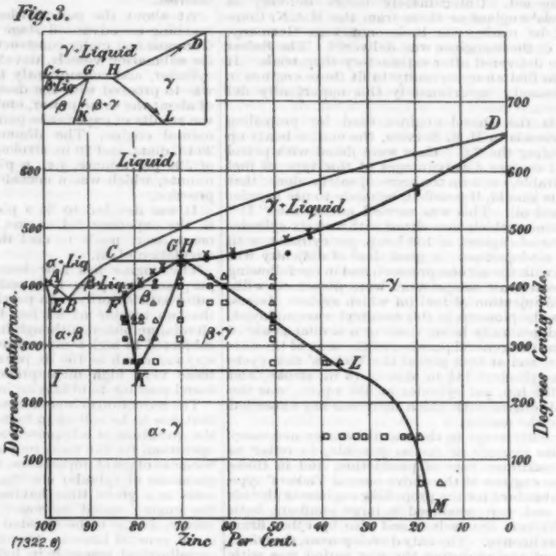


Fig. 3.



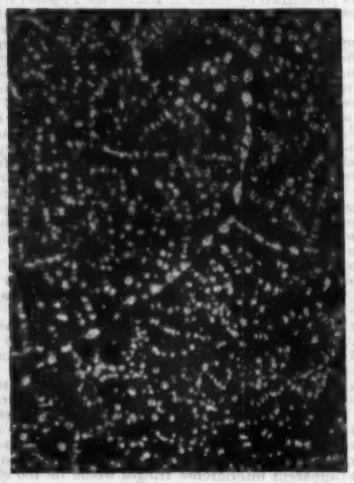


FIG. 4. × 600. 70 PER CENT. ZINC—SLOWLY COOLED TO 284 DEG. CENT. QUENCHED IN WATER.

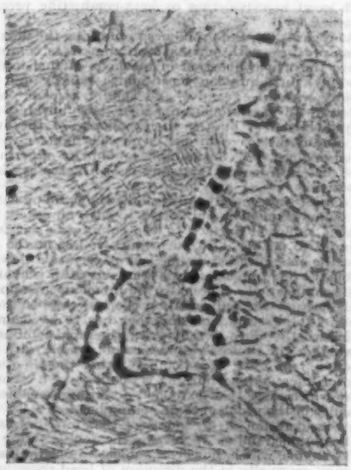


FIG. 5. × 600. 50 PER CENT. ZINC—SLOWLY COOLED TO 284 DEG. CENT. QUENCHED IN WATER.

ETCH 4 PER CENT. ALCOHOLIC HNO_3.

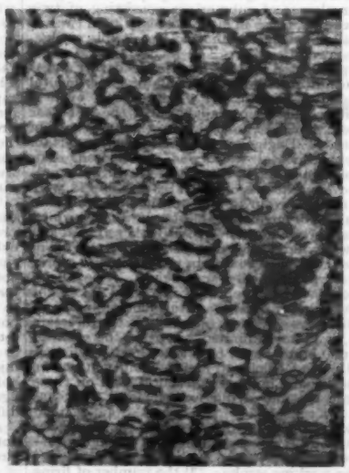


FIG. 6. × 1,500. 50 PER CENT. ZINC—SLOWLY COOLED TO 200 DEG. CENT. QUENCHED IN WATER.

* Abstract of a paper read before the Institute of Metals on Thursday, March 9, 1922.

duplex structures produced in this way are very definite, and the relative amounts of light and dark etching constituents are such as would be expected immediately above a horizontal such as K L. Attention may be drawn to the very fine structures of the alloys, in spite of the fact that they have been cooled at extremely low rates. It is to be expected that greater rates of cooling would produce still finer structures which could only be resolved under the highest powers of the microscope.

In another experiment, alloys containing 50 per cent. and 70 per cent. of zinc, respectively, were slowly cooled from a little below the line G H to temperatures a little below the line K L, after which they were quenched. The structure of an alloy containing 50 per cent. of zinc,

Determination of the Solidus.—The inconsistencies between the microstructures obtained by the authors and the existing diagrams, led them to undertake a re-determination of the solidus over a wide range of composition, from 81 per cent. of zinc to 20 per cent. of zinc. It appeared to them probable that the differences between their experiments and those of previous workers could only be due to the fact that in their experiments they had annealed the alloys for a very long time at high temperature in order to obtain structural uniformity. The effect of lack of homogeneity in the alloys of such a system would be to prolong the lines G H and K L towards the aluminium end of the diagram, and to give a solidus lower than the true solidus of the equilibrium diagram.

temperature for 10 minutes, and quenched. This treatment was repeated, the annealing temperature being raised by 5 deg. C. at each re-treatment, until microscopic examination showed that melting of the alloy had begun. The results are indicated in Fig. 3. In this figure, the black circles indicate temperatures at which the alloys were completely solid; the crosses indicate temperatures at which the alloys were partly molten. The typical appearance of an alloy quenched from just above the solidus is shown in Fig. 7, under a magnification of 600 diameters, which represents the alloy containing 79 per cent. of zinc quenched from 410 deg. C. Melting is indicated by dark etching intercrystalline films and by spots within the crystal grains. The results obtained differ appreciably from those of previous workers.

FIG. 7. × 600. 79 PER CENT. ZINC. QUENCHED FROM 410 DEG. CENT., SHOWING PRESENCE OF LIQUID AT QUENCHING TEMPERATURE.

FIG. 8. × 600. 82 PER CENT. ZINC. QUENCHED FROM 345 DEG. CENT. α (WHITE) + β (DARK.)

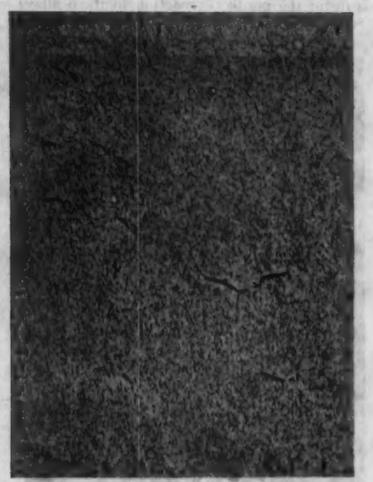


FIG. 9. × 300. 81 PER CENT. ZINC—SLOWLY COOLED TO 270 DEG. CENT. QUENCHED IN WATER. β + LITTLE α.

FIG. 10. × 600. 79 PER CENT. ZINC—SLOWLY COOLED TO 270 DEG. CENT. QUENCHED IN WATER. β + LITTLE γ.

FIG. 11. × 300. 71 PER CENT. ZINC—SLOWLY COOLED TO 400 DEG. CENT. QUENCHED IN WATER. β + TRACE OF γ.

FIG. 12. × 600. 78 PER CENT. ZINC—SLOWLY COOLED TO 304 DEG. CENT. QUENCHED IN WATER. β + LITTLE γ.

ETCH 4 PER CENT. ALCOHOLIC HNO_3.

after being cooled very slowly from 400 deg. to 200 deg. C. in 24 hours, is shown in Fig. 6, under a magnification of 1,500 diameters. It consists of light etching areas, and areas with a duplex lamellar structure similar to that of many eutectoids. In the same way, an alloy containing 70 per cent. of zinc, cooled from 380 deg. to 248 deg. C. in 16 hours, possesses a similar structure, with the exception that the amount of light etching constituent is less.

The above experiments indicate that between 443 deg. and 256 deg. C. alloys containing between 50 per cent. and 70 per cent. of zinc become resolved into two constituents, one of which appears white after etching with 4 per cent. alcoholic nitric acid, and the other of which appears dark. At 256 deg. C. the dark etching constituent appears to decompose into a duplex mass having the appearance of a eutectoid. It appears probable, therefore, that the dark etching constituent, which exists above 256deg. C., is the β constituent found by Rosenhain and Archbutt.

In the author's experiments, alloys of the required composition were cast into chill moulds, and the ingots thus obtained were annealed for a prolonged period. A Haughton-Hanson thermostat furnace* was used, and the authors wish to emphasise the value of this apparatus, by means of which it is possible to carry out prolonged annealing experiments that would otherwise be almost too tedious to be practicable. In the case of alloys containing from 82 per cent. to 75 per cent. of zinc, this annealing consisted in an exposure of 12 days to a temperature of 345 deg. C. In the case of alloys with a lower zinc content, and annealing for 11 days at 416 deg. C. was adopted. The alloys were quenched after this treatment to avoid appreciable segregation during the reactions which take place on cooling. For the purpose of determining the solidus, small specimens were cut from these chill-castings, heated rapidly to a temperature a little below the solidus, maintained at that

They indicate that the line G H should terminate at approximately 70 per cent. of zinc, and that beyond this point the peritectic reaction will only occur in alloys which are not in complete equilibrium. In the same way, the eutectic line E F ends at about 82 per cent. of zinc. These differences are almost certainly due to differences in the length of the preliminary annealing given to the specimens. The sloping solidus F G, which extends from 82 per cent. to 70 per cent. of zinc, indicates by its point of intersection with C H the composition of the phase formed at this peritectic line.

The actual shape of the diagram in the neighbourhood of the point H in Fig. 3 is not very distinct, on account of the large number of lines which radiate from this region. In the top left-hand corner of the diagram the authors give, on an enlarged scale, the constitutional diagram for this region. It will be observed that they draw a short horizontal line between the points G H, although the actual position and number of the points on the solidus, determined by experiment, are not in

* ENGINEERING, vol. c, page 378, and vol. civ, page 412.

themselves sufficient to justify this line. That such a horizontal line must exist is, however, indicated by other considerations. In the case of all the alloys that were examined, with one exception, it was observed that, at a temperature immediately below the solidus, each consisted of a single homogeneous solid solution; the alloy containing 70 per cent. of zinc, immediately before it melted, consisted of two constituents, the light etching and dark etching constituents shown in Fig. 4. In fact, it was observed that, at the moment of melting, all three phases β, γ, and liquid—were present in the alloy. Such an observation can only be explained by the existence of a horizontal line to the right of the point G. The sloping solidus H D is now in accordance with the structural observations made on alloys immediately below this line.

The nature of the peritectic reaction in these alloys calls for some further consideration. According to the modification of the diagram now suggested, it consists in a reaction, between liquid of composition C and solid of composition H, to give a solid of composition G; it is further obvious that the actual amount of liquid which takes part in this reaction is very small, and the change in the composition of the solid is but slight, namely, from H to G. This is in accord with the observations of Rosenhain and Archbutt, that the evolution of heat, which accompanies the reaction at this peritectic line, is but slight.

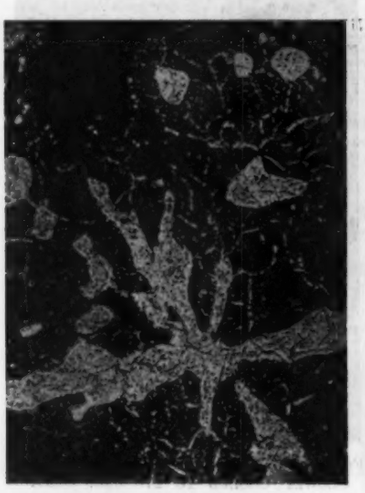


FIG. 13. × 600. 71 PER CENT. ZINC—COOLED TO 304 DEG. CENT. QUENCHED IN WATER. β CONTAINING FINE PARTICLES OF γ, AND γ CONTAINING FINE PARTICLES OF β.

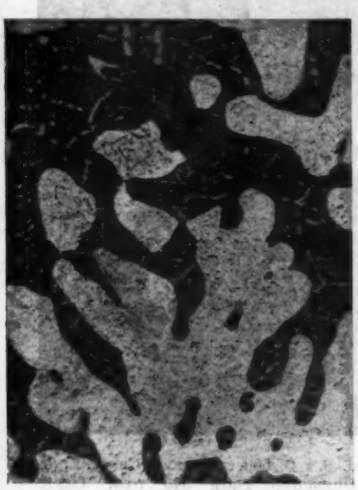


FIG. 14. × 600. 65 PER CENT. ZINC—COOLED TO 304 DEG. CENT. QUENCHED IN WATER. β CONTAINING FINE PARTICLES OF γ, AND γ CONTAINING FINE PARTICLES OF β.

Constitution of the Solid Alloys.—In order to investigate the constitution at temperatures below the solidus, a further series of experiments has been made. Samples of the different alloys, which had previously been subjected to a prolonged annealing just below the solidus, were reheated for a sufficient period to secure equilibrium at the annealing temperature, and were then slowly cooled, at very slow rates, to lower temperatures, from which they were quenched. The constitution at the quenching temperature was then investigated by microscopic examination. The results obtained are indicated in the diagram Fig. 3. In this diagram a duplex structure at any temperature is indicated by a square, while a homogeneous structure is indicated by a triangle. Typical microstructures of these alloys are shown in Figs. 8 to 15. Fig. 8 represents the constitution at 345 deg. C. of the alloy containing 82 per cent. of zinc; the white-etching constituent is the zinc-rich solid solution, and the dark etching (mottled) constituent is β. Figs. 9 and 10 represent alloys containing 81 per cent. and 79 per cent. of zinc respectively, quenched from 270 deg. C. At this temperature the alloy containing 81 per cent. of zinc consists of a ground-mass of β containing a trace of α, while that containing 79 per cent. consists of β containing a trace of γ. Fig. 11, which represents the structure at 400 deg. C., of the alloy containing 71 per cent. of zinc, indicates a ground-mass of β with a trace of γ. Figs. 12 to 14 represent alloys which have been slowly cooled to 304 deg. C., annealed at that temperature for 17 hours, and quenched. The white-etching constituent (γ) gradually increases in amount with increase in the aluminium content. Figs. 13 and 14 are particularly interesting, since each contains areas of γ from which β has separated as the temperature fell, and areas of β from which γ has separated, and these microstructures are completely in accord with the existence of the sloping solubility limits K G and H L.

It is seen that the β field is bounded by lines G K and F K, which meet in the point K, in the horizontal line at 256 deg. C. The nature of the change in the alloys at this temperature is now clear, as it is found to be identical with an ordinary eutectoid transformation; the microstructures of the alloys in which this reaction has taken place are in agreement with this form of diagram, since the decomposition of the β constituent leads to typical "pearlitic" structures, such as are seen in Fig. 6, and were shown, in a beautiful manner, in the paper by Rosenhain and Archbutt. The eutectoid point occurs at approximately 79 per cent. of zinc. The eutectoid line extends towards the aluminium end of the diagram, up to a composition of approximately 35 per cent. of zinc.

An attempt has also been made to determine the constitution below the eutectoid line. Alloys containing from 40 per cent. to 10 per cent. of zinc were heated to a little below the solidus for several days in order to secure uniformity of composition, and were then slowly cooled during about one week to temperatures of 140 deg. C. and 60 deg. C. respectively. They were held at these temperatures for some days and then quenched. The cooling in this case was carried out very slowly, since it was realised that, at the low temperatures involved, alterations in structure and constitution would take place very slowly, and long periods of time would be required in order to permit the necessary diffusion in the solid alloys to take place. The results have fully justified such slow rates of cooling, and it has been found possible to detect changes in constitution at a temperature below 140 deg. C. In the series of alloys quenched at 140 deg. C. considerable difficulty was at first experienced in determining the structure. The alloys all appeared to be homogeneous, but a complete failure to reveal the crystal boundaries by etching led the authors to suspect that the homogeneous appearance under the microscope was not real, and by careful polishing and etching, together with the use of very high-power objectives, they were able to detect the separation of α in an alloy containing only 22 per cent. of zinc. In the alloy containing 20 per cent., quenched at this temperature, the crystal boundaries were readily developed and no signs of precipitated α were seen.

FIG. 15. × 1,500. 24 PER CENT. ZINC—SLOWLY COOLED TO 140 DEG. CENT. QUENCHED IN WATER. α (DARK) + γ (WHITE).

ETCH 4 PER CENT. ALCOHOL HNO_3.

Fig. 15 represents the structure of the alloy containing 24 per cent. of zinc, quenched from 140 deg. C., the magnification being 1,500 diameters. At 60 deg. C. the solubility is further lowered to between 15 per cent. and 20 per cent. zinc.

(To be continued.)

CATALOGUES.

Mechanical Stokers.—Several mechanical stokers are illustrated and described in a catalogue received from Messrs. Meldrums, Limited, Timperley, Manchester.

Internal-Combustion Engines.—A catalogue of small vertical engines for petrol, benzol or gas fuel comes from Messrs. J. Renée and Co., 80, Rue de Meaux, Paris.

Welding Supplies.—A catalogue of welding rods for cast-iron welds and of fluxes for cast-iron, steel, copper aluminium and brass, is to hand from the Suffolk Iron Foundry, Limited, Stowmarket.

Trailer.—A light four-wheeled trailer with both pairs of wheels linked for four-wheel steering and a draw bar attachable to either end, is illustrated in a catalogue to hand from Mr. A. E. Parnacott, Penge-lane, London, S.E. 20.

Electric Furnaces.—A circular inviting those interested to call at their works and bring specimens for heat treatment, has been received from Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1.

Railway Signalling.—An illustrated description of the new signalling system, designed and installed by them for the Liverpool Overhead Railway, has reached us from the Westinghouse Brake and Saxby Signal Company, Limited, 82, York-road, King's Cross, London, N. 1.

Trucks and Ladders.—Two catalogues received from Mr. H. C. Slingsby, 142, Old-street, London, E.C. 1, show a remarkable variety of ladders, steps, trucks, barrows and all such tackle, with many mechanical devices for dealing with articles of exceptional weight or presenting other unusual difficulties in handling.

Disinfectors.—A considerable range of high-pressure steam disinfecting plant is described and illustrated in a 20 page catalogue received from Messrs. Manlove, Alliott and Co., Limited, Nottingham. Various sizes of chambers and fittings for quickly dealing with all the usual kinds of articles are listed.

Rubber Machinery.—Scrap washers, plantation washers, sheeting and marking machines, a hand mangle and a 4,000-ton vulcanising press are amongst the machines illustrated in a catalogue received from Messrs. Henry Berry and Co., Limited, Leeds. An excellent line drawing of the scrap washer is included in the catalogue.

Circuit Breakers.—A new edition of their catalogue of automatic circuit breakers, with a revised price list, is to hand from the General Electric Company, Limited, Kingsway, London, W.C. 2. The catalogue gives full particulars of open and ironclad breakers, extras and spares, automatic battery switches, time switches and current limiters.

Electric Transformers.—We have received from Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. 7, the fifth number of their series of transformer pamphlets, explaining the methods of packing transformers for transport, unpacking, installation and maintenance. Number 7 of the series, discussing the rush of current when switching in, has also come to hand.

Colliery Deck ng Plant.—A fully detailed and illustrated description of the electro-pneumatic decking plant constructed for the Thurcroft Main Colliery, Rotherham, which appeared in these columns on January 27 and February 10 last, has been reprinted by the Westinghouse Brake and Saxby Signal Company, Limited, 82, York-road, King's Cross, London, N. 1.

Mining Machinery.—A journal dealing especially with coal cutting, conveying and other mechanical appliances for mining work, is issued monthly by Messrs. Mavor and Coulson, Limited, 47, Broad-street, Mile End, Glasgow. The contents of the issue for March, of which a copy has been sent to us, are entirely relevant to the subject and of great interest and practical utility to those using such machines.

Fans, Drying Plant, Crushing Machinery, &c.—The Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C., send a catalogue showing examples of the various machines produced by them, including fans, blowers, exhausters, steam turbines, various warming, ventilating and drying equipment, and also grinding, crushing and screening machinery, blacksmiths' forges, &c.

Coal Dust Firing.—A catalogue dealing very fully and clearly with the method of firing coal dust is to hand from Messrs. Simon Carves, Limited, 20, Mount-street, Manchester. The actual firing of coal dust is simpler than ordinary stoking, as also is the method of conveying the fuel, but drying and pulverising plant is necessary with the former. Considerable advantages are claimed in efficiency of combustion. The method of firing is almost as easily regulated as oil or gas firing, which leads to economical working where the load is very variable or intermittent. The catalogue is of special interest at present, and may be read as a technical handbook on the subject.